Volume 14 AUGUST, 1935 Number 8

THE BULLETIN

OF THE

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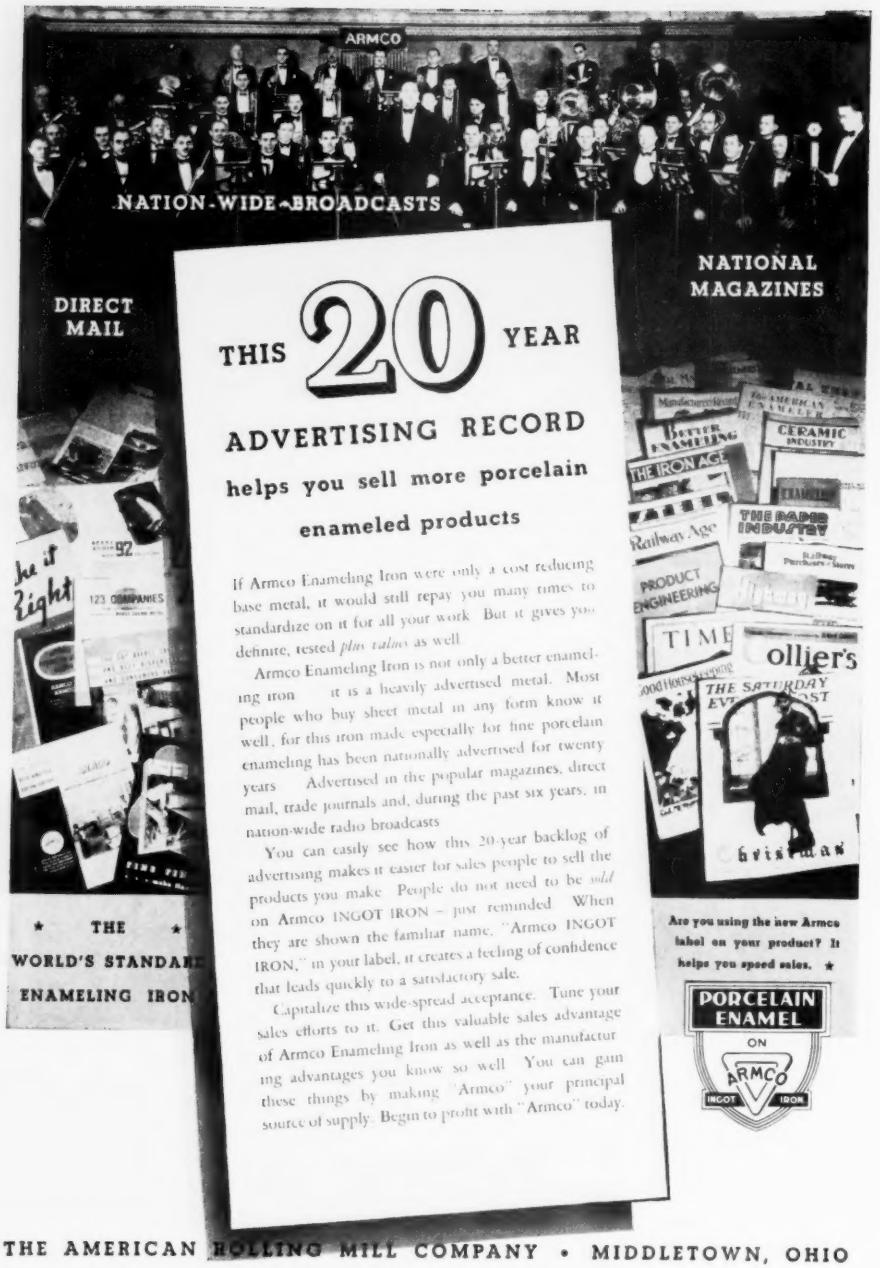
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THE BULLETIN OF THE AMERICAN CERAMIC SOCIETY

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Editorial and Advertising Offices: 2525 N. High St., Columbus, Ohio.
Publication Office: 20th & Northampton Sts., Easton, Pa.
Executive Office: 2525 N. High St., Columbus, Ohio.
Committee on Publications: L. Navias, *Chairman;* L. J. Trostel, M. F. Beecher, R. M. King, Ross C. Purdy

Entered as second-class matter at the post office at Easton, Pa., under the Act of March 3, 1879

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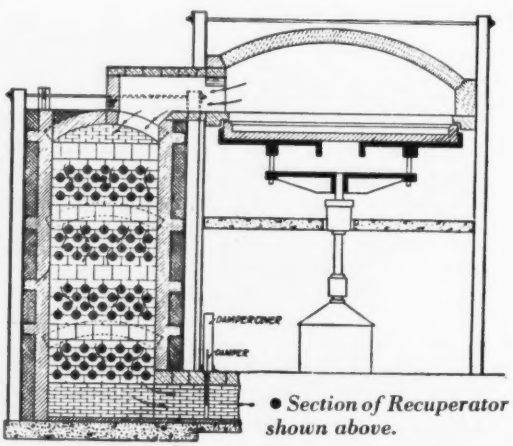

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THE BULLETIN

OF THE AMERICAN CERAMIC SOCIETY

A Monthly Publication Devoted to Proceedings of the Society and Promotion of Coöperative Research of Technical, Scientific, and Art Questions

Volume 14 August, 1935 Number 8

PAPERS AND DISCUSSIONS

FIRING CLAY REFRACTORIES WITH BY-PRODUCT COKE-OVEN GAS*

By C. E. Bales and W. T. Christian

Abstract

By-product coke-oven gas with a Btu value of 550 is now being successfully used in the firing of high heat duty clay refractories. It is more economical than natural gas and there is no difficulty in reaching the required high temperatures. A better looking product and a more uniform firing is secured by the use of this gas than by the use of coal. Combustion is apparently completed in the checkered fire boxes. Details of firing a kiln are given.

I. Introduction

Coal, natural gas, producer gas, and oil have been used in firing refractories but, as far as the writers have been able to learn, the successful use of by-product coke-oven gas for this purpose is of comparatively recent date. A number of years ago a firebrick plant in the Birmingham district made an attempt to use this fuel which was unsuccessful due to the wash water carried along with the gas.

Prior to 1930, the clay refractories at Ironton were fired with No. 6 run-of-mine coal obtained from small mines in the vicinity of the plant. This was a medium-grade coal, fairly high in ash and sulfur. The Btu value was 12,500 and the fusion point of the ash was 2300°F. Naturally there was some trouble with clinkers, and the fusion of the fly ash on some of the brick in the kilns gave them a dirty color. To secure brick of a more pleasing appearance and of more uniform thermal treatment, the management decided to try out gaseous fuels.

Natural gas, averaging 1000 Btu, was available at a fairly reasonably rate. Two round, downdraft kilns were equipped with gas burners of a popular make and this fuel was experimented with for almost a year. Some excellent firings were obtained, but the quantity of gas consumed could not be reduced to a point where the cost would compare favorably with coal-firing costs.

In 1931, unpurified by-product coke-oven gas, averaging 550 Btu was made available for some experimental firings. At first it was thought that some difficulty might be experienced in reaching the high temperature required for finishing the firing on account of the low heat value of this gas, but no such trouble was encountered. This was probably due to the fact that by-product coke-oven gas has a higher flame temperature than natural gas. It is probably true that temperatures as high as or higher than 3100°F, may be obtained with by-product gas, as several coke-plant operators have actually melted silica checker brick.

Two kilns were equipped with very simple burners, and a few changes were made in the fire-box construction. After experimenting with this

* Presented at the Annual Meeting, American Ceramic Society, Buffalo, N. Y., February, 1935 (Refractories Division). Received March 7, 1935.

gas for a year, the results were so satisfactory that arrangements were made to install a permanent gas line to the firebrick plant, and all the kilns were equipped to burn coke-oven gas. Since then, one other firebrick plant in the Kentucky field has started to use this gas.

During the test firings, when a temporary pipe line was used to convey the gas to the kilns, trouble was sometimes encountered with wash water in the gas, but the installation of drip pots and blow-off valves on the permanent line has completely overcome this difficulty. Water in the gas gave the brick a dark brown color.

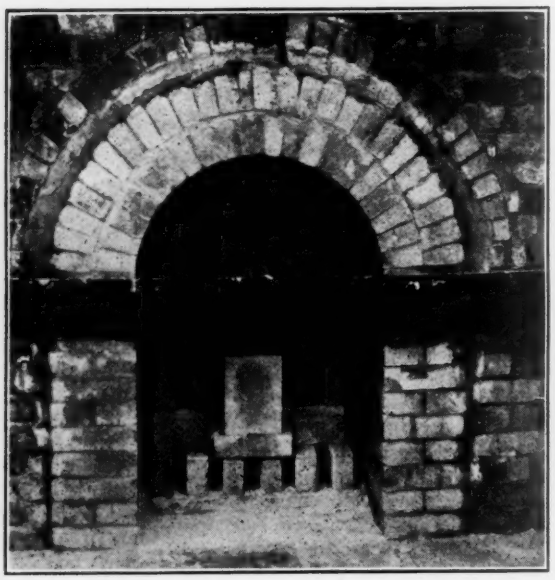

FIG. 1.—A checkered fire box.

II. Properties of By-Product Coke-Oven Gas

By-product coke-oven gas is made by the destructive distillation of bituminous coal in a closed silica-brick oven. It consists essentially of a mixture of hydrogen, methane, carbon monoxide, ethylene, and benzene vapor, diluted with small amounts of other gases. The following analyses are representative of the gas:

CO_2	1.0%	1.5%
C_6H_6	0.6	0.8
C_2H_4	2.0	2.5
O_2	0.9	0.4
CO	4.3	5.5
H_2	57.9	53.5
CH_4	28.4	29.9
N_2	4.9	5.9
Btu	534	553

III. Kiln Equipment

The kilns are of the round, downdraft type, 30 feet in diameter, and each kiln has 10 fire boxes. The ratios of areas of the kiln floor to fire box, floor opening, flue, and stack, are essentially in agreement with those recommended by Bole.[1] It may be that other ratios would prove to be more efficient for gas-fired kilns, but so far no changes have been made in the kiln construction to determine whether or not this would be the case.

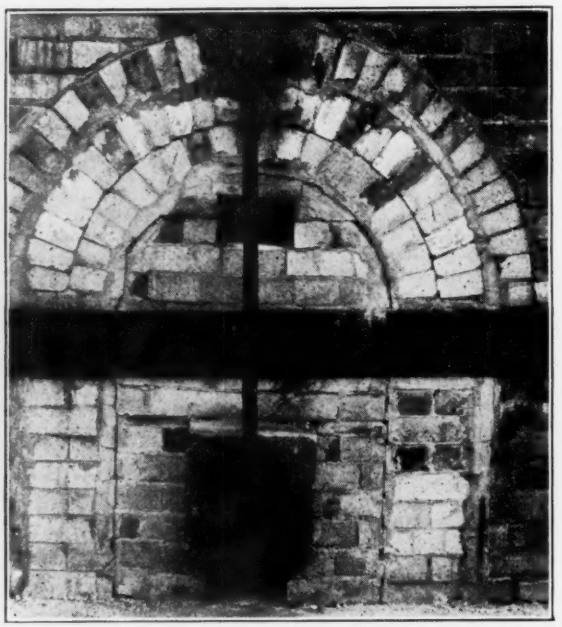

FIG. 2.—Fire-box burner.

In converting the kilns from coal to by-product gas firing, only a few changes were made. All of the grate bars were removed, the clinkers were cleaned off the brickwork, and the fire boxes were filled with 9-inch straights as checker brick (see Fig. 1). Two air openings and one burner opening were provided in the front of each fire box, the rest of the front being bricked up (Fig. 2). The size of the top secondary air opening is 7 by 5 inches, while the size of the bottom secondary air opening is 8 by 6 inches. These air openings are easily closed with brick when it is desired to reduce the amount of excess air.

The burner consists of (1) a 12- by 12-inch fireclay block with a 5-inch diameter hole running

[1] G. A. Bole, *et al.*, "Problems in the Firing of Refractories," *Bur. Mines Bull.*, No. 271 (1927).

through it and (2) a piece of 1-inch pipe, around which has been placed two $^1/_8$-inch iron disks, 6 inches in diameter, which have been punched so that air can be admitted around the gas pipe. The openings in each burner are equivalent to 6 square inches, as it requires at least five volumes of air to burn one volume of by-product coke-oven gas. No air is mixed with the gas in this type of burner, but the mixing occurs in the checkerwork. It is doubtful if a burner of the premix type is desirable for this service, due to the blow-pipe flame and localized heating. In using the simple atmospheric burner, however, it is essential that checker brick be used in the fire boxes to break up the gas and thoroughly mix it with the air to accelerate combustion and to prevent the discoloration of the brick by the luminous flame.

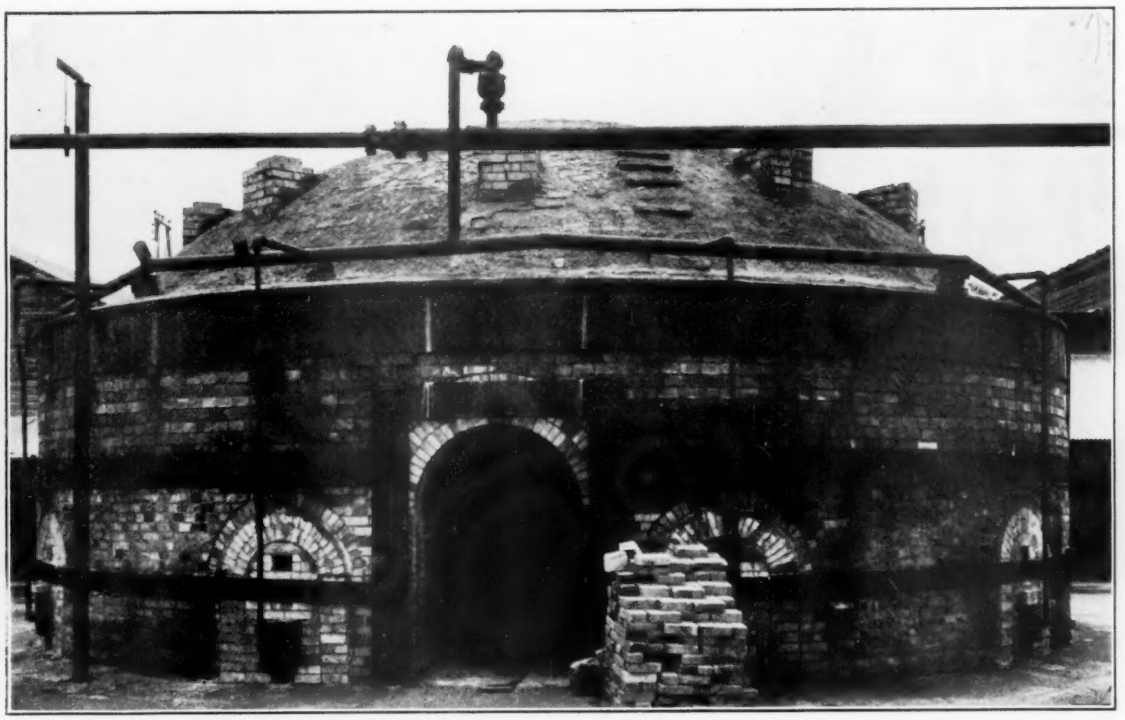

FIG. 3.—By-product gas-fired kiln.

IV. Pipe-Line Equipment

The gas is piped to the firebrick works,[2] a distance of almost a mile, through a 6-inch pipe line. A number of drip pots were installed along this line and they are blown at regular intervals. A pressure regulator is located outside the meter house and the pressure is reduced from 15 to 8 pounds before it passes through the Bailey orifice-type meter. This meter records the rate of flow as well as the temperature and pressure of the gas. The necessary corrections are made to bring the volume of gas to standard conditions of 60°F and 30 inches barometer before the invoice is rendered. A specific-gravity correction is also made.

A 6-inch overhead pipe line runs the entire length of the plant and a 3-inch feeder connects the main line with a 4-inch line running around the crown of each kiln. From this manifold, one-inch pipes run down the kiln and connect with the burners. One-inch cast-iron gate valves are located above each burner. A 3-inch gate valve is located on the crown of each kiln and a master valve, in the meter house, not only as a utility measure but as a precautionary safety measure.

V. Firing Procedure

To use gaseous fuels efficiently and economically, it is necessary that the amount of excess air be reduced to the amount that is actually required in firing the kiln. Any additional

[2] From the plant of the Ironton By-Product Gas Co.

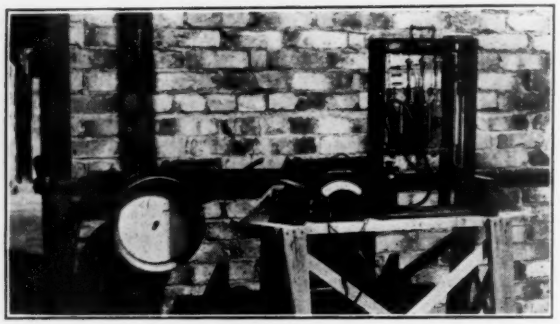

FIG. 5.—Combustion control equipment.

air simply carries valuable heat units up the stack (Fig. 4). After the watersmoking period, it is surprising how little excess air is needed, assuming, of course, that the kiln is of proper design.

In acquiring the technique of using by-product coke-oven gas, it was necessary to rely upon an Orsat gas-analysis apparatus to determine the quantity of air to admit to the kiln. Draft gages and indicating and recording pyrometers were also used (Fig. 5). At present, a recording pyrometer and pyrometric cones are regularly used, with occasional stack-gas analyses to check the firing procedure.

When the kiln is closed, each valve is opened slightly and the burners are lighted. During the first 24 hours about 1200 cubic feet of gas are burned each hour. Sufficient air is admitted through the burner and the bottom air opening to complete combustion and act as a vehicle in carrying out the water-vapor. When a kiln is closed during the late afternoon, the temperature of the crown is about 200°F early the next morning.

The gas is then increased to approximately 2600 cubic feet per hour, but no change is made in the secondary air. This reduces the percentage of excess air as determined by the percentage of CO_2 present in the stack gases. A more accurate way of determining the amount of excess air is to base it on the O_2 content, but the determination of oxygen in stack gases is subject to greater error than the determination of carbon dioxide and the CO_2 method is sufficiently accurate for kiln firing (Fig. 6). The temperature during the 24 hours advances to approximately 400°F, and large volumes of water-vapor issue from the stack.

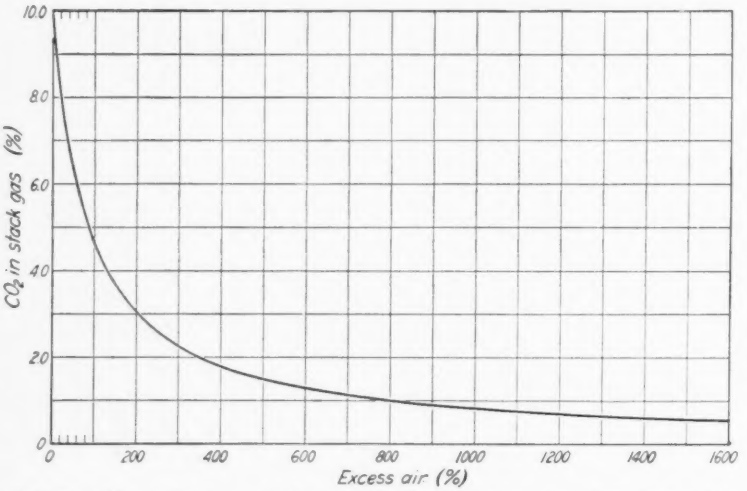

FIG. 6.—Per cent excess air for combustion from per cent CO_2 in stacks.

CO_2	= 1.0%	CO	= 4.3%
C_6H_6	= 0.6	H_2	= 57.9
C_2H_4	= 2.0	CH_4	= 28.4
O_2	= 0.9	N_2	= 4 .9

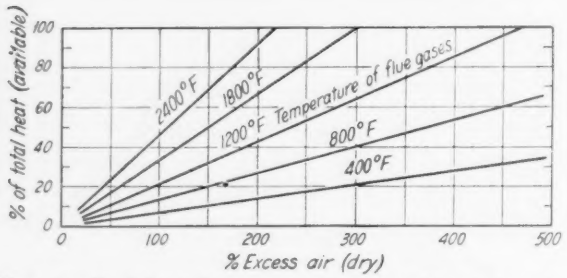

FIG. 4.—Fuel loss due to combustion with excess air.

Gas analysis

CO_2	= 1.0%	CO	= 4.3%
C_6H_6	= 0.6	H_2	= 57.9
C_2H_4	= 2.0	CH_4	= 28.4
O_2	= 0.9	N_2	= 4.9

The products of combustion of coke-oven gas contain a great deal of water-vapor, and for this reason the usual method of inserting a cold iron rod in the flue can not be used to determine when the watersmoking period is completed. For the same reason, it is highly important that the kiln temperature be raised regularly and consistently to prevent condensation of the water-vapor on the brick in the cooler parts of the kiln.

At the end of the second day, the gas is increased to 4000 cubic feet per hour, and the temperature is 650°F early the next morning. The bottom air is then closed off, the gas pressure is increased slightly, and the flow of gas increased to about 6000 cubic feet per hour. By this time there has

been a considerable reduction in the amount of excess air present.

On the morning of the fourth day, the crown temperature will be almost 1000°F, and some blue smoke will issue from the stack. No change is made in the air, but the gas is increased to approximately 8000 cubic feet per hour.

During the next 24 hours, the temperature advances to 1225°F. The blue smoke is heavy by this time, and the gas is increased to 12,000 cubic feet per hour. No change is made in the air openings, but the increase in the gas further reduces the amount of excess air. There is sufficient excess air present, however, to take care of the oxidation of the carbon and sulfur in the brick.

The crown temperature is 1600°F the next morning, and there is heavy blue smoke from the stack. The rate of gas flow is increased to 14,000 cubic feet per hour, which raises the temperature during the next 24 hours to 1925°F. The gas is then increased to 18,000 cubic feet per hour, and the top air hole is opened for 6 hours to prevent overheating of the brick on top and around the rim of the kiln. This also increases the temperature in the bottom of the kiln.

By the following morning the crown reaches a temperature of 2300°F. The gas is increased to 20,000 cubic feet per hour, and the draft is cut three times during the day by removing brick from an opening in the stack. The crown temperature soon advances to 2400°F, which is held until the kiln is completed, as determined by cones. After the draft is completely cut, the gas is reduced and the flashing is started. This is done by closing the burner air openings and opening the top air half-way. There is a pulsating effect in the kiln, small flames can be observed in the peepholes, and a faint gray smoke issues from the stack. During this reduction period, a small amount of CO is present in the stack gases.

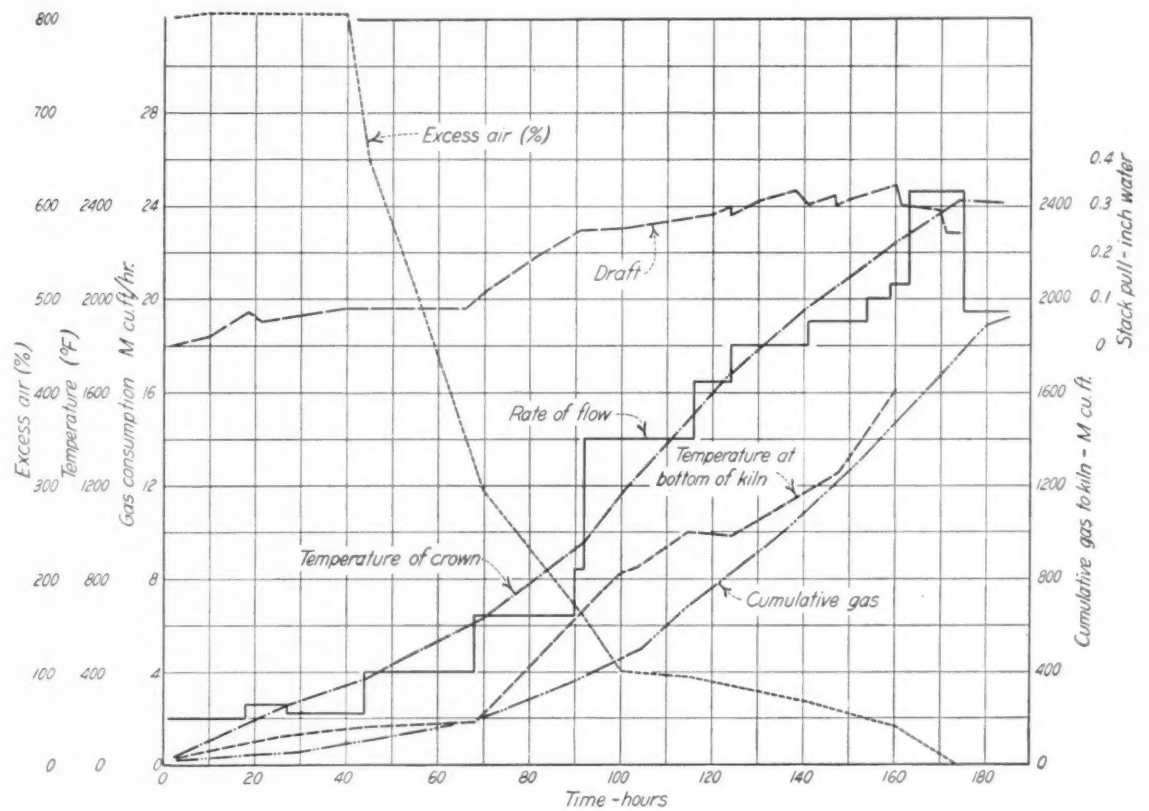

FIG. 7.

The heat distribution in these kilns, as measured by cones, is considered to be very good. On the furnace walls, cone 13 will be over; among the brick in the top of the kiln, cone 11 will be over. In the middle peephole, cone 9 will be flat, with

cone 10 half over. On the floor, cone 8 will be flat.

The average gas consumption is 27,000 cubic feet per thousand 9-inch equivalents.

The combustion of by-product coke-oven gas seems to be completed in the furnace checkerwork; at least no flame can be observed through the peepholes, except during the flashing period. It is believed that these brick are given their thermal treatment by the absorption of heat from clean, completely burned, hot gases flowing at a fairly high velocity.

Figure 7 is a chart showing the data obtained on a typical firing.

The following is a typical log of a by-product gas fired kiln:

LOG OF BY-PRODUCT GAS-FIRED KILN

9/11/34	Kiln No. 5; on fire 4 P.M.	
	Top air closed	Rate of gas flow, 1200 cu. ft./hr.
	Burner open	Pressure 7½ lb.
	Bottom—half closed	
9/12/34	Top air closed	Crown temp. 200°F
7 A.M.	Burner open	Gas increased to 2600 cu. ft./hr.
	Bottom—half closed	Little steam from stack
9/13/34	Top air closed	Crown temp. 375°F
7 A.M.	Burner open	Gas increased to 3800 cu. ft./hr.
	Bottom—half closed	Steaming heavily
		Gas increased to 4200 cu. ft./hr. at 2 P.M.
9/14/34	Top air closed	Crown temp. 650°F
7 A.M.	Burner open	Little steam, and first blue smoke
	Bottom closed	Gas increased to 5200 cu. ft./hr.
		Gas increased to 6000 cu. ft./hr. at 5 P.M.
		Pressure increased to 8½ lb.
9/15/34	Top air closed	Crown temp. 975°F
7 A.M.	Burner open	Some blue smoke
	Bottom closed	Gas increased to 8000 cu. ft./hr.
		Gas increased to 8400 cu. ft./hr. at 1 P.M.
		Pressure increased to 9 lb.
9/16/34	Top air closed	Crown temp. 1225°F
7 A.M.	Burner open	Heavy blue smoke
	Bottom closed	Gas increased to 12,000 cu. ft./hr.
9/17/34	Top closed	Crown temp. 1600°F
7 A.M.	Burner open	Gas increased to 13,900 cu. ft./hr.
	Bottom closed	Blue smoking
9/18/34	Top air closed	Crown temp. 1925°F
7 A.M.		Blue smoking
	Burner open	Gas increased to 18,000 cu. ft./hr.
	Bottom closed	Top air opened for 6 hr., then closed
9/19/34	Top air closed	Crown temp. 2300°F
7 A.M.	Burner open	Gas increased to 20,000 cu. ft./hr.
	Bottom closed	Draft cut in stack opening 7½ in. at 9 A.M.
		Draft cut in stack opening 10 in. at 11 A.M.
		Draft cut in stack opening 24 in. at 7 P.M.
		Crown temp. 2400°F at 9 A.M.
		Kiln off at 10 P.M.
	Excellent firing	
Brick set		68,200 9-in. equivalent
Gas consumed		1,860,000 cu. ft.
Gas/M 9-in. equivalent		27,200 cu. ft.
Time of firing		198 hours

VI. Summary

This paper describes in detail the firing of clay refractories with by-product coke-oven gas. The method will be of interest to those firebrick plants located near coke works.

IRONTON FIRE BRICK COMPANY
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SYMPOSIUM ON CERAMIC WARE FIRING*

R. C. MEEKER, *Chairman* (Kentucky-Tennessee Clay Co.): This symposium on kiln firing had its inception in the early summer months, following which there was a number of exchanges of correspondence.

Whether you agree with Mr. Purdy's use of secondary air, or whether you take offense at his references to "toasting" of the electric kiln, you will all agree that as a stimulator of thought he has no equal.

This program was later developed under the direction of George H. Brown of Rutgers University.

The following papers were presented: "The Physics and Chemistry of the Firing Process," by J. B. Austin[1]; "The Basic Requirements of the Firing Process," by J. A. Doyle[2]; "Effects of Combustion Methods on the Temperature Uniformity of Kilns and Furnaces," by F. O. Suffron[3]; "The Control of Atmosphere and Its Effect on Ware," by M. H. Mawhinney[4]; "The Efficiency of Kilns," by F. A. Whitaker[5]; "Some Uses of the Electric Furnace for Ceramic Firing," by E. J. Harris and Ben A. Bovee.[6]

The meeting was then devoted to discussion.

Discussion

FRANK W. BROOK (Swindell-Dressler Corporation, Pittsburgh): There has been in the United States many electric furnace builders. There are about seven now. These seven have followed a sane policy of limiting the applications only to those jobs where electricity is economical and where the temperature does not exceed an established maximum. Up to about 1929, this maximum was 1850°F. Due to improvements in the heating unit material and a better knowledge of heat application and dispersion rates, it is no problem today to operate electric furnaces continuously up to 2000°F, using metallic heating units.

Publications of today speak freely of metallic heating units operating at 2300°F but do not give any "tieing-in" factor of life. There is little doubt that metallic heating units, given the proper application, will operate continuously for two or three years at a temperature of 2100°F. It becomes then a question of how conservative the furnace builders should be.

For higher temperatures, nonmetallic heating units are required. Claims made here and abroad for new alloys for resistors have not yet been given the test of time. Nonmetallic heating elements require a particular kind of contact to the source of electricity. These contacts have been a source of trouble and expense. In the case of the metallic element, there is no contact trouble. It is necessary merely to bring out the leads triple-ply and bolt or solder them to an electrical conductor out in the cold. This is simple, economical, and long-lived.

A further disadvantage of the nonmetallic heating element is that it disintegrates, which means a change in its resistance, thus requiring a juggling around of new elements, partly used elements, and bad elements. The manufacturers of Globar, for instance, have tackled these problems for several years in a commendable manner, but (for simplicity and economy) are still far from competing with metallic heating units. For example, there is the case of a large installation of several electric heating furnaces in which Globar was used by a manufacturer who wanted to use electricity for many reasons other than economy. The cost of this installation ran into many thousands of dollars, but in the long run, it was not successful and has since been replaced by other means of heating. Had the temperature required in this case been within the safe limits of metallic heating units, none of the difficulties experienced would have been encountered.

All of this can be summed up by saying that for temperatures requiring more than 2000°F in the heating units, electric heating becomes a distinct problem of design and economy.

We must remember that there is no country in the world where natural gas can be purchased for from 30 to 35 cents for one million Btu, and this at present is the next best fuel to electricity from a technical viewpoint. In purity and controllability, however, it is far behind electricity.

Mr. Purdy says that all electric kilns designed to date in America are toasters.

Toasting is brought about by the application of radiant heat. For many years the ceramic industry has been decorating ware by this same process of toasting. My idea about toasting is this: Suppose you take a piece of bread and put it in front of a single strand of electrically heated wire (or a single Globar) and pass a certain amount of electrical energy through this single strand. The electrical energy will raise the temperature in this unit to 2000°F. The result will be a poor piece of toast. In the center, it will have a long thin streak of black tapering out through the various browns to soft white edges.

If, instead of one strand of wire, an electric heating unit, zigzagged up and down, is used and through it is put the same amount of energy, two things will be done. The temperature in the zigzag unit will be much lower, 1400°F, or a nice red glow, and secondly, the heat will be uniformly distributed across the whole face of the bread. The result is a nice, uniform brown, crisp piece of toast.

The significance of this is that you have taken a certain amount of heat and dispersed it uniformly at a low rate of dispersion per square inch of heating unit surface. My principal objection to present day nonmetallic heating units is that they do not, or can not, disperse sufficiently uniform heat over a particular area and at a sufficiently low rate of dispersion. For instance, in engineering pamphlets published by one of the large manufacturers of nonmetallic heating units, a figure for the dispersion rate

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* This discussion was part of the program for the General Session at the Annual Meeting, American Ceramic Society, Buffalo, N. Y., February 18, 1935. Officers of the Materials and Equipment Division presided over this Symposium.

[1] *Bull. Amer. Ceram. Soc.*, **14** [5] 157–65 (1935).
[2] *Ibid.*, [6] 189–93.
[3] *Ibid.*, [6] 197–202.
[4] *Ibid.*, [7] 222–24.
[5] *Ibid.*, [6] 194–97.
[6] *Ibid.*, [7] 219–22.

of about 200 Btu per square inch is given. Conservative furnace manufacturers using metallic heating units rarely exceed one-tenth of this when working at the higher temperatures. The result is that, in the case of the nonmetallic heating units, there is a high-temperature difference between the source of heat and the ware to be heated, which tends toward lack of uniformity in the ware.

In practically all of the European countries, such an excellent fuel as natural gas is unknown and electricity is obtained on a par with other fuels from a cost per Btu point of view and is therefore undoubtedly the fuel to use. Economical necessity has therefore not brought about such a fine degree of engineering as we have in this country. For instance, one of the latest electric decorating kilns in Europe, treating a net load of 5000 pounds per 24 hours, has a gross load of 16,000 pounds. This ratio would be absolutely impossible from a dollars and cents viewpoint in America. An electric decorating kiln we recently installed has a net load of 20,000 pounds per 24 hours and a gross load of 24,000 pounds. This shows a comparison ratio of 1 to 3.2 in the case of the European kiln and of 1 to 1.2 in the American kiln. Converting this ratio into dollars and cents and assuming that electricity would cost the same per kilowatt-hour, the fuel cost in the European kiln is $2^2/_3$ times as much as it is in the American kiln. Both of these kilns are contemporaneous.

There seems to be, at the present time, room for investigation as to how much the time cycle for the particular decorating process can be shortened. In a recently installed kiln it was the definite opinion of expert ceramists and manufacturers that the shortest cycle would be eight hours; any shorter period than that would produce dunting. While installing the kiln, business improved, and by the time the kiln was ready, there was considerable backlog of ware to be treated and the "engineer" in charge took it upon himself to push the kiln, hourly fearing a horrible mess of broken ware. This shortening process continued until a period of $4^3/_4$ hours was reached, but still there was no dunting. The pressure of business eased and the kiln now operates on a 5-hour cycle and has yet to produce a broken piece of ware.

Finally, real development in the higher temperature field of electricity-as-a-fuel will come about when we are able to obtain power at a rate which will justify its use. It need not be as "cheap" as other fuels because of the better product that will result. But these better qualities can demand only a certain price. Many manufacturers will tell you they will not bring any better price. Have they really tried? In other fields, for many years "electricity-produced" has stood for better quality and better prices.

EUGENE D. MILENER (American Gas Association): In Great Britain about three years ago there was a discussion on toast. Toast occupied the front and back pages of English publications. The question was whether a better piece of toast could be made by putting a piece of bread in front of a wire and heating it to 2000° or whether a better piece of toast could be made by having it in a moist heat and atmosphere The records will show that Great Britain decided that toast that had a little bit of atmosphere around it as well as a moderate heat was the best toast.

Some clever fellows in Buffalo capitalized on that subject and produced what they called the Savoy toaster, and during the last few years a number of hotels in Buffalo and elsewhere have installed this toaster, which has a soft flame and the proper atmosphere around it.

We are selling millions of cubic feet of gas every month to the ceramic industry. We have observed the need for something besides the ordinary muffle. We have looked with favor upon alloys in the hope that alloy muffles could be profitably employed. The alloy materials have been improved to a point where they are perfectly satisfactory from 1500 to 1900°. Work is now under way on a unit with all the advantages and none of the disadvantages of electric element heating. I refer to the recent development of gas hot tubes. The steel industry is beginning to look at this development as one of major importance.

The element is simply made in the form of a hollow tube, and gas combustion is carried on inside of it; this gives a radiant surface, like the customary electric element, with the advantage of the 10 to 1 cost ratio for natural gas which Mr. Brook has given. In a short time, I look for it to break into the ceramic industry the way it has into the steel industry.

The American Gas Association has recently signed a contract to install these tubes experimentally in the sheet-steel enamel industry. That work will begin in the next sixty days and it will be carried on with the doors wide open for anyone who cares to see it.

I am sorry that the report covering experimental tests and research work in connection with the application of gas to higher temperatures, particularly in the glazing field, is not ready. As you know, the American Gas Association and several others jointly have been carrying on research and field work for the last four years under the supervision of the Department of Ceramics at Rutgers University and I had hoped that that complete report would be ready in time for this Meeting; it probably will not be ready until some time this summer.

Glost firing is generally carried on in the industry with the muffle-type chamber, which has decided drawbacks. The first question which this Committee considered was whether or not to carry on this work in open fires. We requested a decision from Rutgers University in eighteen months. The reply from the University was that from the ceramic standpoint there is no reason why a perfect glaze can not be secured where it is surrounded by combustion atmosphere.

As a result of this answer, we decided to go on with field work, interpreting that announcement in terms of economical apparatus. But we also wanted to see if we could make some contribution to the technique as well as to economics. Further attention, therefore, was given to research on kilns. First, the subject of time was considered, and it was decided that the time would be based on 24-hour cycles instead of the usual cycles for that type of ware, which are considerably longer. Second, the gas industry has had much experience with the use of walking-beam furnaces. As far as we could find there had been no walking-beam furnaces in the ceramic industry. In fact, in no industry had walking-beam furnaces been regularly used at temperatures of about 2000°F.

The next thing was to study the ratio between the ware

and kiln furniture, which work has been conducted now for nearly three years. When this report is issued it will not be theory; it will be based on calculations and actual data acquired over the years.

The art of applying heat, we believe, is going to take some turns in the next few years that the average ceramist has hardly dreamed of. We are going to find types of kilns, firing, and atmospheres which, up to this time, have been absolutely ignored by the ceramic industry.

J. A. Doyle (W. S. Rockwell Co., New York): We should not lose sight of the fact that the practical problem of the ceramist deals more with the action of heat on the ware itself than with the method of releasing heat from fuel or electricity or of applying it to the ware by radiation, convection, or otherwise.

We are primarily concerned with the problem of producing more uniform ware at lower cost. To solve the problem, we must learn to think more in terms of "heat application," or "heat transfer," to and from the surface of the ware, and talk less in terms of fuel or electricity, kilns, appliances, or products incident to generation, control or conservation of heat, or kiln construction.

We must learn to sense the distinction between evidence of uniform temperature in some part of the kiln, as disclosed by the pyrometer, and the uniformity with which the heat is actually applied to the ware itself.

There is much room for investigation of the cause of unequal firing in electric and fuel kilns indicating a non-uniform temperature due to actual inequalities set up by local radiation or convection.

The influence of "rate" of heating and cooling with reference to physical characteristics of the individual piece, or charge, could well be considered in an effort to improve firing practice.

Let us keep in mind the difference between "burning fuel and burning ware"; and the difference between releasing heat from fuel or electricity and applying heat uniformly to the ware.

Philip Dressler (Swindell-Dressler Corporation, Pittsburgh): I would first of all like to correct Mr. Milener's statement in speaking of the walking-beam furnace installed under the sponsorship of the American Gas Association as being the first developed to operate above 2000°F. Several years before the interest of the A. G. A., a walking-beam kiln was developed, built, and operated by M. E. Gates in the plant of the American Terra Cotta Company at Crystal Lake, Illinois, for firing terra cotta.

In all of the discussions to which we have listened I have had a feeling that the practical aspects of particular problems have been overlooked.

After all, the purpose of the kiln is to fire a piece of ware so that it will be a commercially satisfactory product. There is no one means which will produce satisfactory ware under all conditions for every class of goods. Each individual case has to be considered on its own merit. Sometimes a direct-firing system does the best work, sometimes not.

When I say commercially satisfactory ware, the economic side must also be considered. In one particular case we are firing ware which is worth $10 a pound and in another case, $10 a ton. The particular method of firing and the fuel that can be used in these cases are greatly circumscribed by the economics of the situation.

It can be stated with much justice that with electricity and gas you have the two methods of heating which give the greatest degree of control and the maximum economy in the use of the heating units. Whether you can utilize either of these fuels for a particular kind of ware will depend entirely upon the location of the plant, relative costs of fuels, and the character of the ware itself. These considerations always exist in the firing of any ceramic product.

There has been some discussion of the justification of the use of muffles and whether it is possible to produce certain classes of goods equally well exposed to the atmosphere of combustion. Here again circumstances govern cases. A properly designed muffle tunnel kiln is substantially as efficient (and in many cases more so) as a direct-fired type of kiln because it is inherently easy to secure a high degree of recuperation of the heat of the fired goods in this type of kiln. It is, however, usually somewhat more expensive to build than a direct-fired kiln.

The greatest benefit which the muffle kiln has permitted the ceramic industries to achieve is the elimination of the sagger as a method of protecting the ware and the substitution of a support which is divorced from the function of protection. Ware needs protection from different things in different cases. Where the fuel contains sulfur, its products of combustion, in many cases, will have a detrimental effect on the ware. If the design of the kiln is such that there are localized points of higher than average temperature, this, too, may have an adverse effect upon the ware. In many cases where neither of these effects is present another consideration is paramount.

The statement that you can fire glazed ware satisfactorily in an atmosphere of products of combustion substantially free from sulfur is true, in many cases, only if the atmosphere is absolutely quiescent. Many glazes contain highly volatile elements, particularly lead. When the ware is heated, a layer of vapors is formed next to the surface of the ware which, if undisturbed, protects the surface from further loss from volatilization. If, however, that layer of vapor is swept away in a stream of gas the protection is removed and a progressive volatilization takes place. With many ceramic products this results in the loss of brilliancy and in the development of what is known as "impoverished" glaze. This is particularly true in the case of flat dinnerware, where the glazes are viscous and do not flow appreciably at the highest temperatures reached in the kiln. Such products can not be fired satisfactorily in any form of direct-fired kiln in which there is a stream of gas passing over the surface of the ware, even though those gases *per se* have no harmful effect upon the glaze. For such products, it is necessary to provide some kind of protection whether it be a muffle or a sagger, or what you please, to prevent the movement of gases over the glazed surface. Every potter is aware of this and, to overcome such effects, he coats the inside of the saggers or containers with a soft glaze highly charged with lead, with the object of surrounding the ware with an atmosphere charged with lead fumes.

It is my view that there has been a misconception of this

problem on the part of those connected with the research described by Mr. Milener.

In connection with Mr. Whitaker's remarks on efficiency, he touched, in a mild way, on the recuperation of waste heat from a tunnel kiln as being one of the factors in the overall efficiency of the installation. This is a subject which has been receiving far more attention recently than heretofore.

A well-built tunnel kiln actually shows only a 25% net loss of heat. The remainder is accounted for by the products of combustion and by the so-called excess heat available from the cooling zone. This 25% represents the heat which is lost through the walls of the kiln into the crown or is carried out of the kiln by the ware at the tail end. The remainder (75% of the heat developed) can be harnessed and, in most installations which are being made today, it is harnessed.

The products of combustion can be passed through "heat interchangers" where they heat air. This pure hot air can then be used for drying or heating. As a rule the heat carried out by the products of combustion will represent about 45% of the heat value of the fuel burned in the kiln. Of this heat, about two-thirds (or 30%) can be recovered in the form of hot air.

In a well-designed tunnel kiln, the amount of fuel that is burned is relatively so small when compared to the weight of the ware that the air required for combustion is able to absorb only about one-half of the heat in the ware after it leaves the furnace section, even in those efficient designs where practically all the air used for combustion passes through the cooling zone of the kiln in direct contact with the goods. The result is that if you have no other method of cooling, the ware will come out of the kiln red hot. To take care of this condition all tunnel kiln builders have, in some form or other, an auxiliary method of cooling the ware, which is usually indirect and makes available a supply of pure hot air.

In addition to the heat recovered from the products of combustion, this excess air from the cooling zone represents about another 30% of the heat input into the kiln. Combining the hot air available from both sources you have a total of about 60% of the heat value of all the fuel burned. That is to say, if you are burning 100,000 cubic feet of gas each 24 hours the heat available from the tunnel kiln, in the form of pure hot air, represents the heating value of about 60,000 cubic feet of fuel. Very often, in the case of heavy clay products plants, this is sufficient to dry all of the ware fired in the kiln, and in the other instances it is sufficient to dry the ware and heat the plant.

We recently put a tunnel kiln into operation in Canada, which was equipped with complete heat recovery. The cold there is quite severe. At the end of January, the heat supplied from the tunnel kiln had been entirely sufficient to heat the plant and dry the ware for the whole winter up to that time except for ten hours in which additional steam heat was required. Surprising as it may seem, the savings, which are effected from the use of the waste heat of the kiln in eliminating the need for boilers, are in some cases almost as great as those achieved by the kiln in its primary function of firing the ware.

C. H. Parmelee (Onondaga Pottery Company, Syracuse): I should like to bring attention to a few of the ideas which Mr. Doyle has emphasized.[7] I can risk making the prediction that literally thousands of ceramic heat-treating furnaces will be built within the next twenty-five years, and that, whether they will be electric or gas or what, the trend will be governed by a number of factors, one of which will be serious mistakes made in the first few installations. If there are two or three bad mistakes made by going off a little too hurriedly or by "ballyhoo" (I believe this was his term), it will be a black eye to that trend for a long time. I would therefore urge every furnace builder to take seriously to heart Mr. Doyle's talk on ballyhoo. We should be careful, whether it is gas or Globar or regardless of what it is, that we do not get the viewpoint of high-pressure selling, because the first few installations can be a very big boomerang, as well as what they are intended to be.

M. H. Mawhinney (Salem Engineering Company, Salem, Ohio): I wish to direct your attention to one statement by Mr. Dressler, as to the necessity for quiet atmosphere in glazing. I am in no position to argue about that, but I have seen direct-fired kilns in which brilliant black glaze on tile was produced where the circulation of atmosphere around the tile was vigorous. Since that experience, my thought has been that if the gas and air are uniformly and thoroughly mixed it makes no difference if the circulation is vigorous.

In connection with the fact that direct-fired kilns have been made to produce satisfactory gloss ware, it should be stated that the designer of fuel furnaces is indebted to the electric furnace builders for the idea of dispersion of heat. As a result of their example not only in the ceramic industry but in the steel industry and many others, the trend has been toward multiplicity of burners and fuel in small quantities properly distributed by a large number of burners. We are indebted to the electric furnace builders for that development.

H. R. Straight (Adel Clay Products Company, Adel, Iowa): Mr. Purdy claims that in the firing of kilns with coal, gas, or oil, it is not possible to have combustion completed in the furnace and still fire a charge of ware uniformly. He contends that you must use secondary air which will mix with the combustion gases after they have nearly passed through the ware. There they will be completely mixed and the combustion completed, which gives combustion in the lower or far part of the charge.

That was nicely illustrated at Roseville. They undertook to fire a standard kiln 30 feet in diameter with coal fire from one center furnace or stoker. Mr. Purdy contends that, in order to get uniform heat distribution, the burning of the gases must be completed after they get to the charge and not before. Every one here thus far has contended that the opposite should be the case. I think they are wrong. I think the combustion can be too complete.

George D. Morris (New Castle Refractories Company, New Castle, Pa.): I think that you have been talking on two different subjects; Mr. Straight has periodic kilns in mind and Mr. Brook has been discussing tunnel kilns.

Chairman Meeker: That is true.

Mr. Doyle: I agree with Mr. Morris that we are talk-

[7] See footnote 2.

ing on two different subjects, and, incidentally, we are losing sight of the main subject.

We are not as much concerned with the alleged relative merits of a periodic kiln or continuous kiln or a method of generating heat with fuel or electricity, as with the action of heat upon the surface of the ware, with due regard to variations in design, operation, and method of loading of either type of kiln.

We are primarily concerned with (*a*) the uniformity of transfer of heat to and from the surface of the ware, and (*b*) the method of heating and cooling a batch of ware exposed in a specific manner to the heating or cooling medium.

Dr. Austin[8] is on sound ground in stating the fundamentals affecting transfer of heat to and from the surface of ware. Mr. Purdy is dealing with a method of heating and cooling a quantity of ware exposed in a specific manner. A different method of exposing the charge in the same kiln or an entirely different form of kiln with a different method of

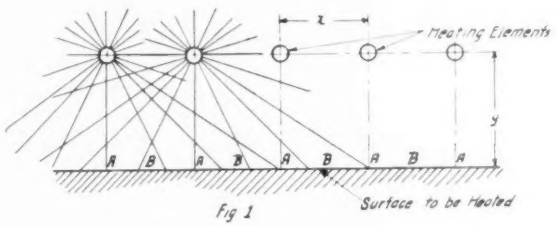

Fig 1

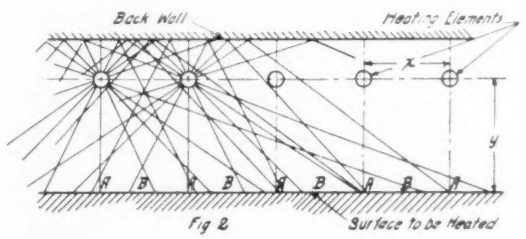

Fig 2

exposure might justify a different method of firing without departing from the fundamentals so ably outlined by Dr. Austin.

Physical factors affecting uniform application of heat to the surface of the ware are as important as thermal factors incident to generation, control, or conservation of heat. Disregard of this fundamental point is responsible for much of the difficulty in industrial heating practice that has too long prevailed in the several industries. It should not be lost sight of in timeworn discussions of the subject, which usually include references to everything related to heat but the action of heat on the ware itself.

We should, like a good cook, "keep an eye on the biscuits," as well as the thermometer on the oven door and bear in mind that the practice of the setting hen in keeping eggs uniformly warm may apply, in principle, in an effort of the ceramist to make a model of Mae West uniformly hot.

Uniform ware, not a uniform pyrometer chart, is the economic objective.

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[8] See footnote 1.

BEN A. BOVEE (Globar Corporation, Niagara Falls): The Globar nonmetallic electric heating element is essentially an element which can be operated at a high watt density. It is not necessary to operate it at high watt densities at all times, nor is it necessary to place heating elements close to the ceramic product to be fired.

If a given number of Globar elements, loaded equally, are spaced equal distances (about five inches) apart in free air, as shown in Fig. 1, and located at the same distance from the surface to be heated, that surface will be heated uniformly. The radiant heat striking the surface directly opposite each element at point *A* will be slightly less than at point *B*, which is midway between points *A*.

By varying the spacing, *x*, and the distance, *y*, it is possible to maintain a uniform temperature on the surface, *A*–*B*–*A*–*B*, etc.

If a refractory wall is placed behind the elements, as shown in Fig. 2, a different condition exists. The wall is heated by radiation from the elements, and it in turn acts as a diffuse radiator. The result is an even heat on the surface *A*–*B*–*A*, etc.

We can reduce the voltage applied to each element and, consequently, the watt density to any desired degree. The term "watt density" refers to the loading in watts per unit area of the radiating surface of a heating element. The circumference of an element times its heating length equals its apparent radiating area. The load in watts divided by the apparent radiating area equals the watt density. The term "apparent radiating area" is used because a Globar heating element, which may appear to be smooth, actually has a rough crystalline surface which increases the actual radiating area. It is possible, by means of voltage regulation, to vary the watt density on the element from a low value up to the limiting permissible value. Instead of decreasing the difference in temperature between the elements and the surface being heated by lowering the watt density on the surface of the elements, the distance from the elements to the surface to be heated can be increased. The energy on the surface being heated depends on the distance from the elements to the surface and upon the surface temperature of the elements, which is a function of the "watt density."

In a periodic furnace, you can increase the temperature at a very slow rate by controlling the power input to the furnace. The difference in temperature between the surface of the material being heated and the interior of that material depends upon its thermal conductivity. If the thermal conductivity of the material is high you can transfer heat to the interior rapidly, and if it is low, the heat transfer must take place slowly.

The subject of time-rate of heating was mentioned in some of the papers on this program.

A complete muffle is sometimes used in gas- and oil-fired furnaces to protect the ware from products of combustion produced by the burning of the fuel. Figure 3 illustrates a cross-section through an electrically heated tunnel kiln. If the temperature on the edges of the ware stacked on the car is uneven due to the spacing of the elements, baffles made of silicon carbide can be placed between the elements and the ware. A space is provided underneath the baffles for direct radiation of heat from the Globar elements to the car top which, in turn, provides bottom heat to the ware.

The baffle plate acts as a secondary radiator. It becomes heated by direct radiation from the elements and in turn radiates heat at a lower rate per unit area to the surface of the ware. It is possible to baffle the elements completely by means of silicon-carbide plates so that no direct radiation from the elements will impinge upon the ware.

The control of the temperature on the surface of the ware is merely a question of furnace design. It is not affected very much by the nature of the heating elements.

Since I am not a ceramic engineer, I am not in a position to say which fuel is best for ceramic firing. I thought it would be interesting, however, to point out that the intensity of heat on the surface of the heating elements is not such an important factor as it was represented to be earlier in the discussion.

CHAIRMAN MEEKER: While we are on the subject of electric kilns, it is my understanding that in Europe there are about a dozen electric kilns operating successfully in firing high-fired porcelain. One of the objectives of

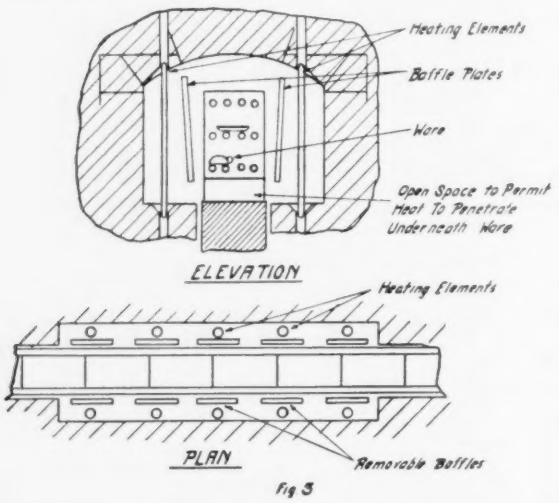


fig 3

the T.V.A. in ceramic work will be the application of electric furnaces to the development of high-fired porcelain. Is it true that in Europe electric furnaces are being used for that work?

PHILIP DRESSLER: I have some information on a kiln operating in Switzerland (the Keramische Industrie in Laufen) for the production of fireclay and vitreous china sanitary ware. This is a Globar installation. The economic situation over there is so different from that in this country that the firing conditions are hardly comparable to ours. They have no natural gas, can not use oil because of its high cost, and have to import all of their coal. Their power costs them 5 mills per kilowatt-hour while rather poor-quality coal costs them $9 per long ton. The electric energy consumption is 0.6 kilowatt-hour per pound of net weight fired.

The ware is fired on a cycle of 42 hours to a temperature of 1280°C. The life of the Globar rods is said to be about three months, and the cost of their maintenance only about 40% of that of the lining of the intermittent coal-fired muffle kilns, in which the ware was previously fired.

It will be readily seen that under such conditions the electric kiln is giving economical and satisfactory service in comparison with the previous practice.

The costs quoted above are converted from the Swiss francs on the basis of 20 cents per franc, the old basis of exchange.

MR. PARMELEE: Mr. Harris, how can you justify the cost of 1 to 3 cents per pound, in view of the fact that other fuels, such as gas or oil, might do the same work in a muffle kiln for possibly one-fourth cent a pound?

EARL J. HARRIS (Carborundum Company, Niagara Falls): There was no attempt made to justify the cost, if other fuels could be used to produce the desired results.

MR. PARMELEE: Could they in a muffle kiln?

MR. HARRIS: In our case we are not able to. I am not with the Globar Company. I am not trying to sell Globar. My paper was meant to show our effort. The first purpose was to provide an emergency unit which would give the kind of ware we wanted in a short time, and in the furnace the actual cost per pound was not the essential thing. It is a furnace for specialties rather than any finished product; in some cases we have found that we can use it as a production unit on a special product of our own that we have had considerable difficulty with in firing by other means.

R. B. KEPLINGER (Metropolitan Paving Brick Company, Canton, Ohio): Mr. Dressler is right when he says that the economics in many specific cases govern and will continue to do so.

Our company makes a cheap, low-grade product. Of course, we use largely coal; we have used oil and we have one type of kiln using powdered coal. We have specific problems in different states where coal rates are high and gas is reasonably cheap. We use ordinary periodic rectangle downdraft kilns. We have one 85-ft. kiln with 12 furnaces on the side, a coal-burning kiln equipped with gas burners.

We are neither combustion engineers nor furnace builders, but we know that, in our experience with coal firing, we must have diffused combustion or delayed combustion (call it what you will) to get uniform thermal treatment inside of that charge.

These gas burners, which we have operated only periodically because of a bad production schedule, are quite expensive. If, to get uniformity of heat distribution, it is necessary to install a number of burners, it would be expensive and a lot of kiln alterations would be necessary. Eventually the economic situation may indicate that the thing to do is to abandon the periodic form of firing and install a tunnel system. I can not see that there is any difference, as far as the principles are concerned, whether periodic, continuous, or tunnel kilns are used.

If the gas people could tell us of some way whereby we can use approximately the same number of furnaces without using a multiplicity of burners on two or three different levels and very short center spacing, I should like to hear about it.

It is difficult to get that authentic information. We have had no experience with gas and only a little experience with oil.

O. L. MADDUX (United Gas and Fuel Company, Hamilton, Canada): There has been, and I think there is now, a place for using multiplicity of burners and there is a

place for another type of burner, that is, delayed combustion. A statement was made here about oxidizing conditions within a kiln in connection with over-ventilation and under-ventilation, *i.e.*, that you could put too much oxygen in the flue gas or you could have not enough. My contention has been borne out by actual results that it is not necessary to have any oxygen in the flue gas as long as there is proper ventilation in the furnace. The purpose of the oxygen is to oxidize the ware and if it is used for that you will not lose any oxygen in the process.

The particular type of combustion I am speaking of, delayed or diffused combustion, has been used successfully in a number of applications. The burner equipment is not expensive. It can be used with the regular furnace settings by firing in what is an ash pit, by insulating, and by building the refractories combustion chamber, so that you get a complete ignition of the gas at that point with a reduced amount of oxygen. The primary and secondary air are taken in at the same point, the secondary air being carried in through the fire doors in the set-up, giving a combustion that will diffuse radiant heat that will equalize itself when it gets in the chamber. These are built up in units for about 15,000 cubic feet of gas an hour.

MR. PARMELEE: While we are on the subject of delayed combustion, a year ago in Syracuse we obtained natural gas at a reasonable rate and converted four downdraft, round periodic kilns to gas, using the Webster Engineering Company's atmospheric tunnel burner. This burner has a number of orifices in the burner tip so directed as to entrain as much air as possible in the Venturi throat of the tunnel with an extra orifice in the center of the burner which can be put on or turned off at will; this orifice injects a small stream of raw gas toward the center of the kiln. These burners were provided in the ash pits, as described by Mr. Maddux. The object of the small orifice in the center of the burner tip was to make possible, at will, an injection of a small stream of raw gas toward the center of the kiln so that this portion of the gas would not be burned until it arrived near the center of the kiln and in the flues under the floor of the kiln. This was done to improve temperature uniformity in the center of the kiln. We can not use this method with our product, even when limiting its use to a temperature above 1400°, at which temperature the hot refractories in the form of saggers in which our ware is placed, would be expected to add to the ability of this type of combustion to occur as rapidly as the gas could come in contact with any oxygen surrounding the saggers in the kiln. We experimented a number of ways and found, with our particular product contained in sealed saggers, that discoloration, or other evidence of insufficient oxidation, occurred on both the biscuit and the glost ware.

HENRY C. KLEYMEYER (Standard Brick and Tile Co., Evansville, Ind.): This whole question has become like the argument of the five blind men about what an elephant is like, each one giving his point of view.

In the War times, the Government said that we could use only one-half of the coal we had been using and that we must learn how to use it more economically. They said we must use a "balanced draft." I went to the engineers in my city and found out that a balanced draft was the dividing of the draft over and under the fire.

My father, who brought me up in the clay business, said, "Now, son, the thing you have got to do is to fire the bottom tiers in your kiln without overfiring the top." I have used both natural gas and coal. We can get a bottom nearly 100% perfect more easily with coal than with gas, because with gas the combustion is too complete in the furnace, and hence heats the kiln by radiation.

By using a gas flame about 3 or 4 feet long, we get a good result. We had always thought if we could see any kind of a blaze at all it would discolor the ware, but we have found that if we let a little blaze into the kiln, the color is not affected and we get better heat distribution.

CHAIRMAN MEEKER: In listening to these papers and discussions, I believe we are pretty well agreed that the economics of the situation, the type of ware to be fired, and the type of kilns available, have a great influence on what sort of heat or fuel is to be used.

CHARLES F. GEIGER (Carborundum Company, Perth Amboy, N. J.): One of the important lessons to be learned from this entire symposium is that brought out this morning by Mr. Doyle to the effect that there is no panacea for *all* of our firing ills or problems. Aside from the economics of the individual instance, we are inclined to believe that our difficulties arise as much from the incorrectness of the manner of applying a given fuel or heating medium as they do from the deficiencies in the fuel or heating medium itself, for any case being considered. This generalization applies to all types of fuel as well as to electric heating, although it is evident that in many localities the cost per Btu of the latter removes it from consideration. We recall that in the relatively early days of oil firing as applied to ceramic products, many difficulties were encountered, and numerous installations were torn out after relatively short periods of usage. Perhaps in these instances the installations were made by men who knew more about firing oil than they did about the proper maturing of the ceramic products that were involved. As a result, we had an improper application of the fuel which, if it had been properly applied, would have worked successfully as later developments have proved in many instances.

From some of the things that have been said here today, the inference may be drawn that data obtained in firing one product or one type of ware may be applied 100% to the firing of many other ceramic products. Experience has shown definitely that this is not the case. It must be remembered that with some ceramic products, at least, the firing is not only a thermal problem but is simultaneously an important chemical problem and in no case may the time-temperature-mass effects be overlooked. By the mass effects, we mean the relative size and thickness of the ware as well as the density of the whole setting structure, whether it be ware alone or ware and furniture of any type. Numerous examples of overlooking this factor were observed in the attempts to apply automatic temperature controllers to tunnel kilns in which there was no uniform weight of ware or ware and setters on each of the cars to be fired. The net result proved that it was not feasible to place the automatic controller element either in the fire box or in the crown of the kiln since the ware did not require a uniform heat because of the great variations in mass

from one car to the next. It did necessitate a time-temperature-mass consideration which was beyond the scope of the temperature-controlling elements.

We see no reason why it should be especially difficult to fire directly many glazed ceramic products with gas, particularly since we know that in a mid-western plant glazed terra cotta has been fired directly and, we believe, successfully for a number of years with gas as a fuel. Moreover we know that glazed sanitary ware is being direct-fired in kilns without muffles and with oil as a fuel. There is one company that has at least fifteen large kilns of this type in which most of its production is so fired. The fact that fifteen such kilns are in operation indicates that the manufacturer is convinced of the quality of the product produced as well as of the economies of direct firing.

Semi-commercial tests on terra cotta, fired directly with oil in kilns of this same type, have resulted in practically 100% color and glaze quality even in the first experimental runs. One terra cotta manufacturer has laid out a battery of such kilns for firing terra cotta; the impression given is that only the dull state of the terra cotta business during the past several years has prevented the adoption of the plan which will be put into effect when business in this field returns to a normal output. The experience of the sanitary manufacturer over an eight-year period has demonstrated a fuel savings of at least 40% as compared with the former oil-fired muffle kilns. There is no reason why comparable saving should not be effected in terra cotta production, and new kilns will probably be installed when there is an adequate balance between the fuel savings possible and the amount of depreciation yet to be written off on the old kilns; or this saving may brought about even sooner because the knowledge of large fuel savings possible with the new kilns will hasten the day of obsolescence of the old ones.

R. L. HARPER (Harper Electric Furnace Corporation, Buffalo, M. Y.): In defense of the work that Mr. FitzGerald did on the Harper kiln, his work was the first attempt in this country, that I know of, to fire bisque ware commercially in an electric tunnel kiln. This was the installation of the semi-commercial single-track tunnel kiln at the Buffalo Pottery in 1926. The kiln was put in as an experimental unit to demonstrate that the different kinds of ware that were made at the pottery could be fired electrically. The kiln was in operation nine months and during that time they used it to fire bisque ware and underglaze and overglaze decorative ware, firing the glazed ware in a single operation. All of these types of ware were fired successfully.

There was, however, some trouble with the operation of the kiln, but for a first installation there was considerably less trouble than would be expected. The reason given by the Buffalo Pottery for not putting in a commercial bisque kiln was the trouble experienced with the terminals. In those days, we used a solid graphite terminal to carry the current into the furnace. As we all know, graphite will burn up if heated when exposed to the air. Since that time, a covering has been developed which successfully protects the terminals.

There has been quite a bit of discussion today regarding "toasting." A point in the discussion that I think has been entirely overlooked is the temperature at which the so-called "toasting" begins. Heat is carried in the lower temperature ranges mainly by convection and in the higher temperature ranges, probably about 90%, by radiation. I think the range at which "toasting" occurs should be pointed out and considered.

We have learned enough about the firing of bisque ware through our work at the Buffalo Pottery to enable us to build a successful commercial kiln. The heating elements that we could use in the kiln could be solid graphite grids, which would enable us to regulate the heat in any part of the kiln to the required temperature.

In designing the continuous bisque kiln we were handicapped, as are all research men, with having little or no previous data with which to work. Our kiln was designed on the time-temperature curve used for periodic-kiln firing of bisque ware with a few changes. When the kiln was put into operation, it was found that a different time-temperature curve was required for electric firing. To accomplish the required changes without redesigning the kiln, the speed of travel of the cars was reduced, which reduced the production. As far as the mechanical principle of the kiln was concerned, however, we fully demonstrated that electric heat could be successfully used, if the cost of power could be justified in the locality.

A tunnel kiln, as we all know, should be run continuously. Due, however, to negligence on the part of the workmen on several occasions, the kiln was shut down to clear up a jam in the tunnel or to make some minor repairs. These unnecessary shut-downs were injurious to the kiln. Nevertheless, even with the poor operation, we had comparatively long life of the elements. As a matter of fact, a set of elements that were in use six months showed very little deterioration, and there were indications that if a kiln were built using the knowledge that we now have, a much longer life could be obtained.

You may say that Mr. FitzGerald's work was a failure, but we consider it anything but that. The Buffalo Pottery kiln proved what it set out to do and that was to fire bisque ware electrically. The kiln was too small to be economical, but the data obtained showed that a larger kiln of an improved design would be economical. It was unfortunate that Mr. FitzGerald left us in 1929 before we had a commercial kiln installation.

JOHN T. JANS (Holcroft & Company, Detroit, Mich.): I represent a company which has probably installed as many Globars as any other company represented here. We have used a great number of them in forging furnaces, chiefly out at the Ford Motor Plant. We have also used them in ceramic kilns.

In the temperature you would encounter in bisque kiln operation, 2300°, the life of the Globar would be around 1300 heating hours, possibly a little longer. To reach this temperature, the bars should be tested so that they are perfect when they go in. After that they increase in resistance to the point where they should be changed. We consider this short life one of the shortcomings of Globar. It is better, however, than it used to be and it is being improved constantly. We consider the Globar the best heating element that can be used in electric heating above 2000°F.

Last summer I received a letter from a friend who is now

connected with the T.V.A. He says that this limitation I put in Globar is entirely too conservative. He said it would be 2000 hours or even more. Our own experience would indicate that you can expect 1300 to 1500 hours under the conditions specified.

Mr. Brook left the impression that you would get a lot of localized heat by the use of the Globar. The Globar, due to limitations in size, would naturally be an element which would be closely spaced. We have used bars, spaced about five inches center-to-center in ceramic kilns. In referring to one of those kilns, Mr. Purdy said "It is a nice kiln but does not give uniform results." The engineer in that plant told me they fire all the samples in that kiln because they are able to reproduce the exact color of the glazes better than they can in their fuel-fired saggered kilns.

Mr. Doyle said that the ceramic industry is far behind the metal industry in the way ceramists fire their product. Here they take a product that has low conductivity and pile it up in great masses. In automobile plants the spring leaves are not put into the furnace, two leaves one on top of the other; they put them in one by one. A little more money is spent for equipment but you get the goods. You must get heat *around* the individual piece.

With a periodic kiln, whatever product you fire, you will have to depend on delayed or diffused combustion. It is a matter of giving it the extra air to complete combustion so that you actually get as much as you can around each piece. If you build smaller furnaces with smaller cross-sections, do not pile the ware so high, and get the heat around it, your results will be much more satisfactory.

We have known of cases where electric heat has been given credit for great improvements in the art of firing when all that has been done is that the heat has been applied to better advantage. I am referring to cases where formerly the ware was stacked on cars and was more or less dependent on side heat.

Follow the lead of the metallurgical industry and pile that stuff on a tray; as far as the firing results go, after experience in decorating firing, I would go on record to say that with a well-designed muffled gas-fired furnace you will get good results (as far as uniformity of firing, brilliancy of color, and general perfection is concerned) that are a stand-off to well-designed electric firing; and in a district where natural gas is 30 cents a thousand I can not see how you can compete against natural gas with electric heating, considering that both kilns are equally well designed.

THE HYDROMETER METHOD FOR MAKING MECHANICAL ANALYSIS OF SOILS*

By George John Bouyoucos

The hydrometer method was presented about seven years ago as a rapid, simple, and reasonably accurate method for making mechanical analyses of soils.[1] Since it was first proposed, it has undergone considerable change and refinement and the method is now used very widely.

The hydrometer method has been extensively studied and compared with the standard pipette method[2] and with other methods, and the results show that it is reliable and accurate and can be used for making mechanical analysis of soils for all practical purposes.

This method has also received a thorough and extensive investigation by the United States Bureau of Public Roads[3] and with certain modifications and refinements, this Bureau has adopted it as its official method.

The final procedure as developed up to date for making mechanical analysis of soils by the method is as follows: Add 50 grams of fine-textured soils or 100 grams of the sand, based on oven-dry condition, to the dispersing cup (Fig. 1). Fill the cup with distilled water to about $1^1/_2$ inches from the top. Add to the contents 5 cc. of a solution of sodium silicate or water glass (3) having a hydrometer reading of 36 at 67°F. If the soil is in lumps, sufficient time must be given to slake and to soak. As a matter of fact, it is well to allow all soils to soak for about 15 minutes before dispersing them. The soils should always be air-dry, because in the wet condition they do not slake. The soaking can be done in a separate vessel and the material then washed into the cup. Connect the cup to the stirring motor, and stir the contents for 5 minutes for sands and

* Received March 1, 1935.

[1](*a*) G. J. Bouyoucos, "The Hydrometer as a New and Rapid Method for Determining Colloidal Content of Soils," *Soil Sci.*, **23,** 319–30 (1927).

(*b*) G. J. Bouyoucos, "The Hydrometer Method for Studying Soils," *ibid.*, **25,** 365–69 (1928).

(*c*) G. J. Bouyoucos, "The Hydrometer Method for Making a Very Detailed Mechanical Analysis of Soils," *ibid.*, **26,** 233–38 (1928).

(*d*) G. J. Bouyoucos, "A Comparison of the Hydrometer Method and the Pipette Method for Making Mechanical Analyses of Soils (with new directions)," *Jour. Amer. Soc. Agron.*, **23,** 747–51 (1930).

[2] G. J. Bouyoucos, "A Comparison between the Pipette Method and the Hydrometer Method for Making Mechanical Analyses of Soil," *Soil Sci.*, **28,** 335–45 (1929).

[3] R. C. Thoreen, "Comments on the Hydrometer Method of Mechanical Analysis," *Public Roads*, **14,** 93–105 (1933).

10 minutes for all other soils. Those soils, however, which are recognized as difficult of dispersion should be dispersed for 20 to 30 minutes or longer. The sands should not be stirred more than 5 minutes because they seem to undergo abrasion.

Pour and wash the contents into the special cylinder. If 50 grams of soil are used, fill the cylinder to the lower mark with the hydrometer in it. If 100 grams of soil are used, fill the cup to the upper mark with the hydrometer in it. Only distilled water should be used. Then take

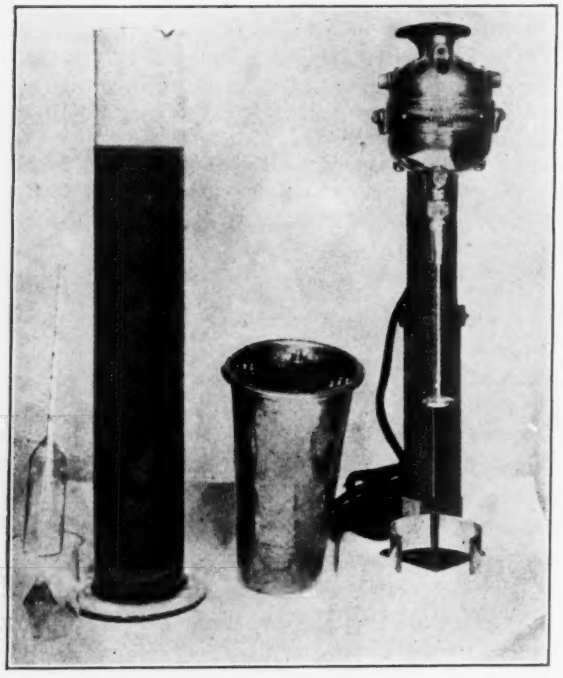


FIG. 1.—The dispersing machine, special cup, special cylinder, and soil hydrometer. The paddle is screwed to the stirring rod and can be replaced when it becomes worn.

the hydrometer out, place the palm of one hand on the mouth of the cylinder and shake the contents vigorously, turning the cylinder upside down and back several times. Place the cylinder quickly on the table and note the time immediately. At the desired period put the hydrometer in the suspension column, record the reading, and then take it out again. There is a tendency for slight amounts of soil material to settle on the shoulder of the hydrometer, and it is better not to leave it in continuously for all readings. Each time the hydrometer is used, it should be clean.

At every hydrometer reading, the temperature of the suspension should be measured. Great care must be taken, however, not to disturb too much the suspension column in putting in and taking out the hydrometer and the thermometer. For every 1°F above or below 67°F, apply a temperature correction of 0.2 graduation on the hydrometer. This temperature correction, however, is only an approximation, as it tends to vary somewhat with extreme concentrations of soil suspensions and also with extreme variations of temperature. Probably, the most accurate hydrometer readings are taken near the temperature of 67°F, which is the temperature at which the hydrometer was calibrated in actual soil suspensions. Extreme temperatures such as 100°F and 50°F should be avoided. If possible, temperatures should be above 67°F rather than below. For temperatures above 67°F, the corresponding amount of correction is added to the hydrometer reading, and for temperatures below 67°F, the corresponding amount is subtracted. The corrected hydrometer reading is then divided by the weight of soil taken and multiplied by 100, the result being the percentage of material still in suspension.

The hydrometer method can not subdivide the sands into their various fractions but can only determine their combined or total amount. Various experimental tests seem to show that the total combined sands of a soil can be ascertained more accurately by taking a hydrometer reading at the end of 40 seconds. A correct reading can be easily made in this short period except in some organic soils which have a tendency to produce froth on the top of the column after being shaken, in which case a correct hydrometer reading is not always possible. One way to overcome this difficulty is to add a drop or two of amyl alcohol before shaking. The determination of the combined sand should be considered only as approximately correct.

Where a subdivision of the sands is required, the following procedure may be used: At the conclusion of the final hydrometer reading, the suspension is washed on a No. 200 sieve. That portion retained on the No. 200 sieve is dried and analyzed on a set of sieves, consisting of one each of Nos. 20-, 40-, 60-, and 140-mesh.

The hydrometer was calibrated in actual soil suspensions consisting of an average loam soil. Its readings, therefore, are quite accurate. It was found difficult to calibrate the range from

0 to 10 grams per liter, however, and readings in this range are not so accurate as in the rest of the range. In this range, readings are about 1 gram per liter too high. It is advisable, therefore, to subtract 1 gram per liter from all hydrometer readings below 9.9 grams per liter before correcting for temperature.

A unique feature of the hydrometer method is the fact that the personal element is reduced to a minimum. The one important thing to watch is the condition of the paddle on the stirring rod. Practically the whole success of the hydrometer method depends upon a complete dispersion of the soil, and a complete dispersion can be obtained only when the paddle on the stirring rod or shaft is in good condition. The paddle that has been used heretofore in the method wears out very easily and becomes flat and small. In this condition its efficiency is practically gone and the soils are not properly dispersed and consequently the results are not correct. In order to eliminate this serious weakness in the method, a new paddle or button has been adopted and placed on the stirring rod. When this paddle becomes worn it can be unscrewed from the shaft and replaced with a new one. This arrangement, besides providing a paddle that is wear-resistant, also obviates the necessity of changing the stirring rod in order to change the paddle as has been the case heretofore. The paddles are inexpensive and can be changed frequently. It is strongly urged upon all those who are now using the old stirrer to replace it with the new one shown in Fig. 1.

Another important point is that the cup should have baffles in it. Without the baffles the soils can not be dispersed easily.

To calculate the conventional amount of combined sand (1.0–0.05 mm.), silt (0.05–0.005 mm.), and clay (0.005–000 mm.) and the finer clay (0.002–0.000 mm.) as determined by the hydrometer method, the procedure is as follows:

The corrected hydrometer reading at the end of 40 seconds is divided by the amount of absolute dry soils taken and is multiplied by 100. The result is percentage of material still in suspension at the end of 40 seconds. This percentage is subtracted from 100 and, the result, is the percentage of material that settled out at the end of 40 seconds, which is supposed to represent all the sand in the soil. The corrected hydrometer reading at the end of one hour is also divided by the weight of soil sample and multiplied by 100. The result is percentage of material still in suspension and is considered to be the conventional clay (0.005–0.000 mm.). The percentage of the conventional silt is obtained by subtracting the clay from 100 and, from this result, subtracting again the percentage of sand. To obtain the finer clay (0.002 mm.), it is only necessary to divide the correct hydrometer reading at the end of 2 hours by the weight of the soil sample and multiply by 100. The organic matter content and the carbonate content are not determined by the method.

It is thus seen that by means of the hydrometer method almost a complete mechanical analysis of soils can be made in only 1 or 2 hours, with the expenditure of very little time and effort.

From all studies and examinations thus far made, it seems that the hydrometer method is reasonably accurate and reliable on all soils that are properly dispersed and properly stabilized by the reagent. It seems to be especially accurate in the coarse clay fraction (0.005 mm.). In the finer clay portion (0.002 mm.), it may not be so accurate in some soils that have a large amount of their finer material just slightly above the 0.002-mm. size. In such soils the hydrometer method indicates a larger content of the 0.002-mm. fraction than the pipette method, but the difference may not be very large.

In peats and mucks, the hydrometer method is not very reliable, first, because these materials are almost impossible to disperse, and second, because they have a smaller specific gravity and the hydrometer was calibrated on average normal loam soils. The method, however, seems to be quite accurate on mineral soils containing a moderately high organic matter content, provided the latter is well decomposed and is completely dispersed. As previously shown, mineral soils containing a high organic matter content in an incompletely decomposed state should be first treated with hydrogen peroxide.

In materials such as bentonite and fullers' earth, the hydrometer method may not be very successful because these materials tend to gelatinize and emulsify and cause the hydrometer to stick and not float normally and freely as it does in a true suspension.

It is advisable to wash very alkaline soils before using them for analysis, or a correction should

be applied for the salts if present in appreciable amounts.

By taking hydrometer readings continuously or every so often, a complete distribution curve of size particles of soils and their respective amounts can be readily and reliably obtained.

The hydrometer method, therefore, would seem to give most, if not all, of the essential information required for all practical purposes, and because of its great rapidity, simplicity, and reasonable accuracy, it should meet a great need.

NOTE: On account of the many inquiries received as to the price of the hydrometer method outfit, and where it may be obtained, the following information is given:

The dispersing machine and cup (cost, about $22) are handled by the Hamilton Beach Co., Racine, Wis.

The hydrometer and cylinder (cost, about $5.00) are handled by the Taylor Instrument Co., Rochester, N. Y

MICHIGAN STATE COLLEGE OF AGRICULTURE
AND APPLIED SCIENCE
EAST LANSING, MICHIGAN

A CORRELATION BETWEEN THE FREEZING AND THAWING TEST AND THE SODIUM-SULFATE TEST FOR SOME IOWA CLAYS*

BY RAY ALLEN

ABSTRACT

The freezing and thawing test and the sodium-sulfate test were run on a group of commercial Iowa clays. A modification of the method used in previous work resulted in a fair correlation between the two tests. The procedure used gives approximately one freezing and thawing cycle equal to one sodium-sulfate test cycle.

I. Introduction

Previous work on this subject was done by W. J. Schlick and R. W. Crum and reported by Staley.[1] The results of their tests indicated that an immersion test using a 15% solution of sodium sulfate is equivalent to approximately two and one-half cycles of freezing and thawing. Hence with the idea in mind of equalizing the two tests, the present ones were carried out using a 10% solution of sulfate and a more severe freezing test.

II. Samples

Five Iowa clays were used for the tests, *viz.*, (1) Boone stoneware clay, formerly used in a stoneware plant, (2) Lehigh sandy clay, used by the Lehigh Sewer Pipe & Tile Co., (3) Lehigh special clay, sent to the Department of Ceramic Engineering for testing its possibilities for stoneware and terra cotta, (4) Kalo clay, used by Kalo Brick & Tile Co., and, (5) Scranton clay, a commercial pottery clay.

The clays were ground in a dry pan, screened through a 20-mesh screen, and tempered in a wet pan. The trial pieces were pressed in a plaster mold; the green trials were $8^1/_2$ by 2 by 2 inches.

For No. 1 clay, 10 trials were fired to cone 08 and 10 to cone 8; for No. 2 clay, 10 were fired to cone 8; for No. 3 clay, 10 were fired to cone 8; for No. 4 clay, 10 were fired to cone 08 and 10 to cone 01; for No. 5 clay, 10 were fired to cone 08 and 10 to cone 2.

The porosity of each test piece was determined by the standard procedure[2] with the following average firing results: No. 1 clay at cone 8 12.2%, at cone 08 23.7%; No. 2 clay at cone 8 24.3%; No. 3 clay at cone 8 7.7%; No. 4 clay at cone 08 23.1%, at cone 01 11.1%; No. 5 clay at cone 2 16.5%, at cone 08 26.7%.

III. Apparatus

The accelerated freezing and thawing tests were carried on in an automatically controlled refrigerator in the ice-cream laboratory of Iowa State College.

The sodium-sulfate tests were made in the drier (shown in Fig. 1) which was a wooden box lined with $^1/_4$ inch of asbestos board. The heating elements were 2 Hoskins FH-204 nichrome hairpins. These hairpins were connected to a Duncan transformer running on regular 110-volt,

* Received January 27, 1934.

[1] H. F. Staley, "Comparison between Sodium Sulfate and Freezing Tests for Drain Tile," *Trans. Amer. Ceram. Soc.*, **18**, 642 (1916).

[2] *Jour. Amer. Ceram. Soc.*, **11** [6] 456 (1928).

60-cycle current, which supplied voltages from 10 to 70.

This transformer was used in these tests because it was available, but cheap electric hot plates, rheostat control, or a number of large-sized electric lamps, so arranged as to form a controllable resistance, would serve equally as well.

IV. Procedure

For the accelerated freezing and thawing test five samples of each firing were subjected to alternate freezing and thawing. The pieces were placed in the refrigerator at 5 to 10°F for 12 hours. They were then put in a tank of water at a temperature slightly under 212°F. The

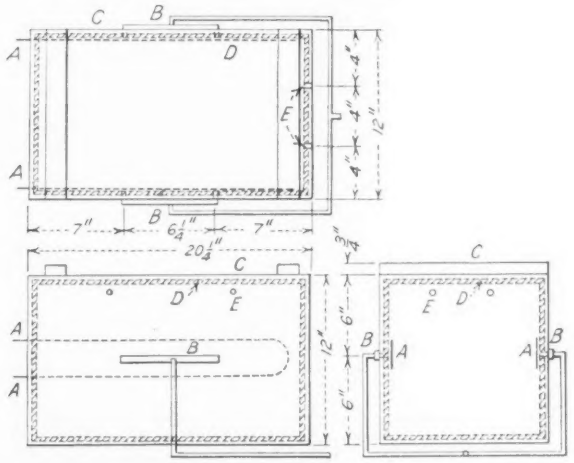


FIG. 1.—*A*, Hoskins FH-204 nichrome hairpin; *B*, air inlet pipe; *C*, outer box; *D*, 1/4-in. asbestos board insulation; *E*, air outlet holes.

pieces were subjected to 50 cycles of this treatment and examined carefully after every 5 cycles.

For the sodium-sulfate test, 5 samples of each firing were boiled in a 10% solution of sodium sulfate for 2 hours and allowed to cool to room temperature. The concentration was maintained by checking the specific gravity after each cycle. The pieces were then placed in the drier and heated to 100°C for one hour, cooled to 80°C, and held at that temperature for four hours. It was found that a voltage of 25 from the transformer maintained a temperature of 100 to 105°C, while a voltage of 20 maintained a temperature of 80 to 85°C in the drier. The pieces were subjected to 50 cycles of this treatment and were carefully examined after every 5 cycles.

V. Results

Clay No. 1 fired to cone 8, clay No. 3 fired to cone 8, and clay No. 4 fired to cone 01 showed no visible deterioration at the finish of 50 cycles of each test.

There proved to be a fair correlation between the two tests on the five clay samples that were affected by the treatment.

Of No. 1 clay fired to cone 08, 4 pieces failed from the sulfate test in the cycle range 40 to 50 and 5 failed from freezing and thawing in the range 40 to 50.

Of No. 2 clay fired to cone 8, 4 pieces failed from the sulfate test in the range 45 to 50 and three failed from the freezing and thawing in the range 40 to 45.

Of No. 4 clay fired to cone 08, 5 failed from the sulfate test in the range 40 to 50 and 3 failed from the freezing and thawing in the range 45 to 50.

Of No. 5 clay fired to cone 2, 4 pieces failed from the sulfate test in the range 40 to 50 and 5 failed from the freezing and thawing in the range 35 to 45.

Of No. 5 clay fired to cone 08, 5 failed from the sulfate test in the range 30 to 35 and 4 failed from freezing and thawing in the range 30 to 35.

There was no visible effect upon samples having less than 11% porosity. This is somewhat higher than the limiting porosity reported in previous work.

NOTE: Owing to a common-sense handling of a situation, the Iowa Highway Commission permits a higher absorption in the drain tile produced in the northern portion of Iowa because experience has demonstrated that the limey clays of that region must be so dealt with.

VI. Summary and Conclusion

Since the clays tested are representative of the clays generally used in the production of structural materials and vary greatly in their characteristics, the sodium-sulfate test, using a 10% sodium-sulfate solution and 50 cycles treatment, appears to be a reasonable substitute for the freezing and thawing test. Many clay-plant driers should duplicate rather well the temperatures used in the drying box. The equipment needed is less costly and less troublesome than the freezing and thawing method demands.

Acknowledgment

This work was done under the guidance of Paul E. Cox who contributed suggestions and coöperation in the development of the technique.

DEPARTMENT OE CERAMIC ENGINEERING
IOWA STATE COLLEGE
AMES, IOWA

ACTIVITIES OF THE SOCIETY

CORPORATION SUPPORT OF THE AMERICAN CERAMIC SOCIETY

The ceramic Corporation supporters of the American Ceramic Society, paying as a minimum $25.00 annually, are listed below. Some of them are paying two and even four times this sum, many of them also maintaining several Personal memberships for members of their staff.

Reason for Corporation Members

(1) The benefits from activities of this Society accrue in financial ways most largely to Corporations, and (2) the cost of publications per personal member alone exceeds the Personal dues.

This Society Is Economically Operated

The Income and Expense Statement for June 29 shows that the Society is managed very conservatively. It is operating within a limited budget. This Society could, with profit to all concerned, extend its activities.

Those who know the labor and cost involved, wonder how this Society puts out three publications and operates so inexpensively.

Benefits That Accrue

The American Ceramic Society is the only effective and economical means devisable for maintaining coöperation in searching for fundamental science facts and applying them to problems of ceramic-ware production.

This Society is a continuation or postgraduate school in ceramic art, science, and technology. Many, without formal collegiate training, have developed proficiency in ceramic science and technology and in capabilities as ceramic engineers and technologists by participating in the activities of this Society. There are many with collegiate training in the *fundamental sciences* who, because of their membership in this Society, have become well-informed specialists in ceramic science and technology.

Those who have had formal collegiate training in *ceramic technology and engineering* and have maintained a membership in this Society have progressed in capabilities so that they are holding responsible positions today in the ceramic industries, while those ceramic graduates who have *not* availed themselves of this continuation of educational training have failed to progress and many of them are not now known in ceramics.

Science and its industrial application is moving so swiftly that the "rule-of-thumb control" of ceramic-ware production is rapidly disappearing. Those ceramic corporations that employ members of this Society not only are keeping abreast but also are making their contributions to the progress made.

The maintaining of a Corporation membership in this Society is a sharing in the support of the research promotion which has enabled our ceramic industries to hold their own, not only with like ware but also in competition with nonceramic products.

The securing of a larger Corporation membership support is imperative because of the greater need today for ceramic research.

Every ceramic corporation should be sharing in the cost of this coöperative effort to obtain for our ceramic industries that knowledge of ways and means of producing ware of the highest quality at the lowest costs.

HERE ARE THE CORPORATIONS NOW HOLDING CORPORATION MEMBERSHIPS*

Abbé Engineering Co., H. F. Kleinfeldt, 50 Church St., New York, N. Y.

A C Spark Plug Co., Taine G. McDougal, Flint, Mich.

Akron Porcelain Co., F. W. Butler, Akron, Ohio.

American Gas Assn., C. G. Segeler, 420 Lexington Ave., New York, N. Y.

American Lava Corp., Paul J. Kruesi, Chattanooga, Tenn.

American Potash & Chemical Corp., Clark M. Dennis, 70 Pine St., New York, N. Y.

American Refractories Institute, Dorothy Texter Kincaid, 2202 Oliver Bldg., Pittsburgh, Pa.

American Rolling Mill Co., F. J. Sutphen, Middletown, Ohio.

American Sheet & Tin Plate Co., J. C. Eckel, 902 Frick Bldg., Pittsburgh, Pa.

American Stove Co., Arthur Stockstrom, St. Louis, Mo.

Amsler-Morton Co., Paul L. Geer, 720 Fulton Bldg., Pittsburgh, Pa.

Babcock & Wilcox Co., A. M. Kohler, 85 Liberty St. New York, N. Y.

Ball Brothers Co., George A. Ball, Muncie, Ind.

Baltimore Enamel & Novelty Co., H. B. Little, Box E-4, Baltimore, Md.

Bausch & Lomb Optical Co., Murray Scott, Rochester, N. Y.

Beach Enameling Co., H. L. Beach, Coshocton, Ohio.

Bonnot Co., B. T. Bonnot, Canton, Ohio.

Buck Glass Co., R. A. Blunt, Fort Ave. & Lawrence St., Baltimore, Md.

Buffalo Pottery, L. H. Bown, Buffalo, N. Y.

Canton Stamping & Enameling Co., E. F. Hoerger, Canton, Ohio.

Carborundum Co., Frank J. Tone, Niagara Falls, N. Y.

Carr-Lowrey Glass Co., Clarence B. McComas, Baltimore, Md.

Celo Mines, Inc., V. L. Mattson, Burnsville, N. C.

Ceramic Color & Chemical Mfg. Co., W. F. Wenning, New Brighton, Pa.

* The Corporation voting representative follows the Corporation name.

Certain-Teed Products Corp., H. H. Van Hagan, Military Road, Buffalo, N. Y.
Champion Spark Plug Co., J. A. Jeffery, Ceramic Division, Detroit, Mich.
Chicago Hardware Foundry Co., J. A. De Celle, North Chicago, Ill.
N. Clark & Sons, G. D. Clark, 116 Natoma St., San Francisco, Calif.
Clay Products Assn., George D. Lenth, 111 W. Washington St., Chicago, Ill.
Clay Products Co., Inc., of Indiana, George Shoemaker, Brazil, Ind.
Columbian Enameling & Stamping Co., W. M. Gorby, Terre Haute, Ind.
Coors Porcelain Co., A. Coors, Jr., Golden, Colo.
Corhart Refractories Co., Inc., H. M. Kraner, 16th & Lee Sts., Louisville, Ky.
Corning Glass Works, J. T. Littleton, Corning, N. Y.
Cortland Grinding Wheels Co., C. B. Tilton, Chester, Mass.
Crane Enamelware Co., A. M. Nelson, Chattanooga, Tenn
Crooksville China Co., Guy E. Crooks, Crooksville, Ohio.
Crossman Co., F. M. Crossman, Jr., South Amboy, N. J.
Crown Potteries Co., J. P. Wendt, Evansville, Ind.

Denver Sewer Pipe & Clay Co., W. J. Geddes, Broadway at Curtis, Denver, Colo.
Detroit Electric Furnace Co., C. M. Weinheimer, 825 W. Elizabeth St., Detroit, Mich.
Devilbiss Manufacturing Co., E. F. Frey, Toledo, Ohio.
Joseph Dixon Crucible Co., H. P. Smith, Jersey City, N. J.
B. F. Drakenfeld & Co., Scott J. Courtney, 45–47 Park Place, New York, N. Y.
E. I. du Pont de Nemours & Co., Thomas H. McKeown, R. & H. Chemical Dept., Wilmington, Del.

Edgar Plastic Kaolin Co., Albert C. Edgar, Metuchen, N. J.
Electro Refractories & Alloys Corp., L. U. Milward, 662 Andrews Bldg., Buffalo, N. Y.
Empire Sheet & Tin Plate Co., Charles H. Stamm, Mansfield, Ohio.
Charles Engelhard, Inc., W. O. Hebler, 90 Chestnut St., Newark, N. J.
English China Clays Sales Corp., 551 Fifth Ave., New York, N. Y.
Eureka Flint & Spar Co., Herreld D. Thropp, Box 266, Trenton, N. J.
The Exlon Co., R. K. Brier, Blasdell, N. Y.

Federal Seaboard Terra Cotta Corp., Perth Amboy, N. J.
Ferro Enamel Corp., R. A. Weaver, 4150 E. 56th St., Cleveland, Ohio.
Fostoria Glass Co., W. F. Curtis, Moundsville, W. Va.

General Ceramics Co., Perry D. Helser, R.C.A. Bldg., 30 Rockefeller Plaza, New York, N. Y.
W. S. George Pottery Co., W. S. George, East Palestine, Ohio.
"Giesche" Fabryka Porcelany Sp. Akc., M. P. Mehan, Katowice-Bogucice, Poland.
Gillinder Brothers, Inc., J. Fletcher Gillinder, Port Jervis, N. Y.
Gladding, McBean & Co., Atholl McBean, 660 Market St., San Francisco, Calif.
Gleason-Tiebout Glass Co., C. H. Tiebout, 59–54th St., Maspeth, N. Y.
Glenwood Range Co., J. L. Anthony, Taunton, Mass.
Golding-Keene Co., Charles E. Golding, Keene, N. H.
Great Lakes Steel Corp., Conrad W. Given, Tecumseh Road, Ecorse, Detroit, Mich.
A. P. Green Fire Brick Co., R. S. Bradley, Mexico, Mo.

Haeger Potteries, Inc., E. H. Haeger, Dundee, Ill.
Hall China Co., M. W. Thompson, East Liverpool, Ohio.
Hanley Co., C. T. Morrow, Summerville, Pa.
Hanovia Chemical & Mfg. Co., W. Riehl, Chestnut St. and N. J. R. R. Ave., Newark, N. J.
Hardinge Co., Inc., Francis E. Finch, York, Pa.
Harshaw Chemical Co., D. G. Pierce, Intelligence Service Div., 1945 E. 97th St., Cleveland, Ohio.
Hartford-Empire Co., F. Goodwin Smith, P. O. Box 1620, Hartford, Conn.
Hazel-Atlas Glass Co., J. H. McNash, Wheeling, W. Va.
O. Hommel Co., O. Hommel, 209–4th Ave., Pittsburgh, Pa.
L. J. Houze Convex Glass Co., Roger J. Houze, Point Marion, Pa.

Illinois Clay Products Co., Otis L. Jones, 214 Barber Bldg., Joliet, Ill.
Ingram-Richardson Mfg. Co., of Indiana, Inc., C. P. Scripture, Frankfort, Ind.
International Smelting & Refining Co., F. O. Case, 151st and McCook Ave., East Chicago, Ind.
Irish Glass Bottle Co., Ltd., F. Winkelmann, Charlotte Quay, Dublin, Ireland.
Isolantite, Inc., R. S. Bicknell, 343 Cortlandt St., Belleville, N. J.

Kentucky Clay Mining Co., W. J. Watkins, Mayfield, Ky.
Kentucky-Tennessee Clay Co., R. C. Meeker, Paris, Tenn.
Edwin M. Knowles China Co., J. W. Hepplewhite, Newell, W. Va.
Kohler Co., Carl J. Kohler, Kohler, Wis.
Koppers Construction Co., Carl D. Ulmer, Research Division, 713 Koppers Bldg., Pittsburgh, Pa.

Laclede-Christy Clay Products Co., W. J. Westphalen, 1711 Ambassador Bldg., St. Louis, Mo.
Lapp Insulator Co., Inc., G. W. Lapp, Leroy, N. Y.
Homer Laughlin China Co., Joseph Wells, East Liverpool, Ohio.
Lava Crucible Co. of Pittsburgh, Furman South, Jr., 627 Wabash Bldg., Pittsburgh, Pa.
Lee Clay Products Co., Martin S. Bowne, Clearfield, Ky.
Libbey Glass Manufacturing Co., H. R. Black, W. & L. E. R. R., Ash St., Toledo, Ohio.
A. J. Lindemann & Hoverson Co., W. C. Lindemann, Milwaukee, Wis.
Locke Insulator Corp., F. H. Reagan, Box A, Baltimore, Md.

London Brick Co. & Forders, Ltd., C. W. D. Rowe, Africa House, Kingsway, London W. C. 2, England.

McLain Fire Brick Co., J. B. Blewett, Central Office, Wellsville, Ohio.
Macbeth-Evans Glass Co., H. H. Blau, Charleroi, Pa.
Maryland Glass Corp., Louis C. Roche, Morrell Park Sta., Baltimore, Md.
Matawan Tile Co., B. K. Eskesen, Matawan, N. J.
Metal & Thermit Corp., Eugen Becher, 120 Broadway, New York, N. Y.
Mississippi Glass Co., R. D. Humphreys, 220 Fifth Ave., New York, N. Y.
Mitchell Clay Manufacturing Co., W. F. Knoesel, 5627 Manchester Ave., St. Louis, Mo.
Moore & Munger, Murray Rushmore, 33 Rector St., New York, N. Y.
Mosaic Tile Co., R. P. Herrold, Zanesville, Ohio.
Mt. Clemens Pottery Co., C. E. Doll, Mt. Clemens, Mich.

National Aluminate Corp., G. J. Fink, 6216 W. 66th Place, Chicago, Ill.
National Engineering Co., L. B. Knight, Jr., 549 W. Washington Blvd., Chicago, Ill.
National Fireproofing Corp., R. A. Shipley, 1134 Fulton Bldg., Pittsburgh, Pa.
National Lime and Stone Co., L. G. Love, First National Bldg., Findlay, Ohio.
Newbold Silica Fire Brick Co., St. James Bldg., 109 Elizabeth St., Sydney, Australia.
New Castle Refractories Co., R. W. Rowland, New Castle, Pa.
New Jersey Porcelain Co., Stephen Wenczel, P. O. Box 908, Trenton, N. J.
New Jersey Pulverizing Co., H. F. Spier, 205 W. 34th St., New York, N. Y.
Nippon Toki Kaisha, Ltd., Jiro Ishikawa, Noritake, Nagoya City, Japan.
North American Refractories Co., E. M. Weinfurtner, National City Bank Bldg., Cleveland, Ohio.
North State Feldspar Corp., W. F. Deneen, Micaville, N. C.
Norton Co., Arthur T. Malm, Worcester, Mass.

Ohio Insulator Co., M. W. Manz, Barberton, Ohio.
Onondaga Pottery Co., B. E. Salisbury, Syracuse, N. Y.
Edward Orton, Jr., Ceramic Foundation, George A. Bole, 1445 Summit St., Columbus, Ohio.
Owens-Illinois Glass Co., R. G. Hunter, Alton, Ill.
Owens-Illinois Pacific Coast Co., Otto Rosenstein, 15th & Folsom Sts., San Francisco, Calif.

Pacific Clay Products Co., Roy Lacy, 306 West Ave. 26, Los Angeles, Calif.
Pass & Seymour, Inc., J. W. Brooks, Solvay, N. Y.
Pennsylvania Pulverizing Co., W. J. Woods, Lewistown, Pa.
Pennsylvania Salt Mfg. Co., J. E. Hutchinson, 641 Union Trust Bldg., Pittsburgh, Pa.
Pfaudler Co., O. I. Chormann, Rochester, N. Y.
Pittsburgh Plate Glass Co., C. E. Fulton, Creighton, Pa.
Porcelain Enamel & Mfg. Co., Richard Türk, Eastern & Pemco Aves., Baltimore, Md.
Potters Supply Co., Dewitt C. Irwin, East Liverpool, Ohio.

Quigley Company, Inc., W. S. Quigley, 56 West 45th St., New York, N. Y.

Republic Steel Corp., L. D. Mercer, Republic Bldg., Youngstown, Ohio.
Rickmann & Rappe, E. Rickmann, Chemische Fabriken, Koln-Kalk, Germany.
W. A. Riddell Co., L. Haigh, Bucyrus, Ohio.
Roberts & Mander Stove Co., Donald H. Fuller, Hatboro, Pa.
Rookwood Pottery Co., John D. Wareham, Mount Adams, Cincinnati, Ohio.
Roseville Pottery Co., Mrs. George Young, Zanesville, Ohio.
Ross-Tacony Crucible Co., K. E. Buck, Tacony, Philadelphia, Pa.
Rundle Mfg. Co., H. J. Held, 3905 River Rd., Camden, N. J.
Rustless Iron Co., Ltd., H. Whitaker, Trico Works, Keighley, England.

Salem China Co., F. W. McKee, Salem, Ohio.
Shenango Pottery Co., James M. Smith, New Castle, Pa.
Simonds Worden White Co., F. R. Henry, N. Summit St. & Negley Place, Dayton, Ohio.
Simplex Engineering Co., C. E. Frazier, Washington Trust Bldg., Washington, Pa.
Smith & Stone, Ltd., B. Stone, Georgetown, Ont., Canada.
Solvay Process Co., L. W. Peterson, Syracuse, N. Y.
Southern California Gas Co., Lee Holtz, 1700 Santa Fe Ave., Los Angeles, Calif.
H. C. Spinks Clay Co., R. B. Carothers, 52 Monmouth St., Newport, Ky.
Square D Co., H. S. Freeman, 6060 Rivard St., Detroit, Mich.
Standard Sanitary Mfg. Co., Erwin Sohn, 1541 S. 7th St., Louisville, Ky.
Star Porcelain Co., F. F. Gardinor, Muirhead Ave., Trenton, N. J.
Stark Brick Co., E. A. Stewart, Box 258, Canton, Ohio.
J. C. Steele & Sons, H. O. Steele, Statesville, N. C.
Sur Enamel & Stamping Works, Ltd., M. M. Sur, 9 Middle Rd., Entally, Calcutta, India.
Swindell-Dressler Corp., Philip Dressler, P. O. Box 1888, Pittsburgh, Pa.

Taylor, Smith & Taylor Co., W. L. Smith, Jr., Chester, W. Va.
Toyo Toki Kwaisha Shinozaki, S. Momoki, Kokura City, Japan.
Trenton Potteries, James Hamilton, P. O. Box 141, Trenton, N. J.
W. S. Tyler Co., F. P. Nickerson, Cleveland, Ohio.

United Clay Mines Corp., K. E. Ward, Oakland & Prospect Sts., Trenton, N. J.
Universal Clay Products Co., Sandusky, Ohio.
Universal Dental Co., Joseph Kohn, 48th & Brown Sts., Philadelphia, Pa.

Universal Sanitary Mfg. Co., W. Keith McAfee, New Castle, Pa.

Verreries Souchon Neuvesel, Siège Social, à Lyon 8, 10 rue de la Bourse, France.
Vesuvius Crucible Co., Francis L. Arensberg, Box 29, Swissvale, Pa.
Vitreous Enameling Co., Edgar H. Weil, 71st & Grant Ave., Cleveland, Ohio.
Vitro Mfg. Co., Arved Strod, Corliss Sta., Pittsburgh, Pa.
Vollrath Co., J. C. Vollrath, Sheboygan, Wis.
Waltham Grinding Wheel Co., M. F. Cunningham, Waltham, Mass.
Weber Electric Co., August Weber, Jr., Schenectady, N. Y.
Western Electric Co., L. I. Shaw, Hawthorne Sta., Chicago, Ill.
Westinghouse Electric & Mfg. Co., E. H. Fritz, Derry, Pa.
Wheeling Steel Corp., W. F. Copp, Portsmouth, Ohio.
Whitall-Tatum Co., George S. Bacon, Millville, N. J.
Will Corporation, H. J. Coleman, Rochester, N. Y.

COMPARATIVE STATEMENT OF INCOME AND FXPENSES

First Six Months Ending June 29, 1935

	Total Last Year	1/2 Last Year	1/2 This Year	Year 1935 Publication	Year 1935 General
Income					
Dues, Corporation	$ 4093.30	$ 1956.65	$ 2218.38	$ 540.00	$1678.38
Dues, Personal	11666.89	5699.20	7574.71	3377.00	4197.71
Divisions	182.87	122.81			
	15943.06	7778.66	9793.09	3917.00	5876.09
Journals (current)	3260.15	1508.82	2008.59	2008.59	
Journals (old)	358.05	376.59	529.75	529.75	
	3618.20	1885.41	2538.34	2538.34	
Advertising (net)	7424.95	3593.65	4275.57	4275.57	
Miscellaneous publications	72.25		153.00	153.00	
Reprints	464.83	317.24	273.02	273.02	
Contributions	126.32		5.00		5.00
Society Key			9.17		9.17
Annual Meeting			460.16		460.16
Interest	246.27	313.47	199.16	99.58	99.58
	8334.62	4224.36	5375.08	4801.17	573.91
TOTAL INCOME	$27895.88	$13888.43	$17706.51	$11256.51	$6450.00
Expenses					
Cost of printing	$12475.81	$ 5918.26	$ 5971.12	$ 5971.12	
Abstracts	690.20	434.15	339.45	339.45	
Reprints		52.79	372.15	372.15	
Editor's office expense	935.18	446.48	580.73	580.73	
	14101.19	6851.68	7263.45	7263.45	
Salaries	12598.13	6231.13	6439.50	3775.00	2664.50
Office expense (Secretary)	1535.08	767.04	550.57		550.57
Postage	1294.71	599.24	768.61		768.61
Office rental	960.00	480.00	480.00	240.00	240.00
Miscellaneous expense	25.39	15.63	25.83		25.83
Divisional expense			33.97		33.97
Annual Meeting	160.00	97.50			
Depreciation on equipment	178.64	89.32	90.00	45.00	45.00
Bad accounts	100.77	66.00	55.00	27.50	27.50
Tax on checks		2.36			
	16852.72	8348.22	8443.48	4087.50	4355.98
TOTAL EXPENSES	$30953.91	$15199.90	$15706.93	$11350.95	$4355.98
GAIN OR (LOSS)	($3058.03)	($1311.47)	1999.58	($94.44)	$2094.02

NEW MEMBERS

Corporation

Electro Refractories and Alloys Corp., L. U. Milward, voter, 662 Andrews Bldg., Buffalo, N. Y.
Exolon Company, R. K. Brier, voter, Blasdell, N. Y.
Illinois Clay Products Co., Otis L. Jones, voter, 214 Barber Bldg., Joliet, Ill.

Personal

Buchanan, Ross, Mayer China Co., Beaver Falls, Pa.; Superintendent.
Henning, Walter V., 167 West Fourth St., Mansfield, Ohio; Westinghouse Mansfield Vitreous Enamel Co.
Hubbard, Arthur E., 51 Braxted Park, London S W 16, England; heat insulation engineer.
Medert, Warren C., 2611 S. Terrace Ave., Columbus, Ohio; foreman, Owens-Illinois Glass Co.
Miller, Charles T., 2535 E. Main St., Springfield, Ohio.
Pearch, William M., 1608 Nichol Ave., Anderson, Ind.; National Tile Co.
Raimondo, Matthew J., 1688½, Murchison St., Los Angeles, Calif.; Pacific Clay Products.
Schneider, Henry R., North State Feldspar Corp., Micaville, N. C.
Staley, F. R., Max B. Miller & Co., Inc., 501 Fifth Ave., New York, N. Y.; research chemist.

Student

Frauenfelder, Edward H., Missouri School of Mines.
Haff, Robert S., Jr., Virginia Polytechnic Institute.
Hester, Weston T., University of Illinois.
McNamara, Edward P., New York State College of Ceramics.

MEMBERSHIP WORKERS' RECORD

Corporation

G. S. Diamond	2	O. L. Jones	1

Personal

R. E. Hanna	1	W. E. S. Turner	1
V. V. Kelsey	1	A. S. Watts	2
F. A. McCann	1	Office	2
R. C. Meeker	1		
		Total	9

Student

A. I. Andrews	1	J. W. Whittemore	1
C. M. Dodd	1		
S. R. Scholes	1	Total	4
		Grand Total	**16**

WE MAKE PROGRESS

	June 20	July 23
Paid in full		
Personal	1159	1185
Corporation	180	184
Honorary, Life, and Complimentary	29	27
Deferred personal	49	45
Part-payment personal	80	75
Subscribers	416	423
Advertisers	34	35
Current Sales	200	200
TOTAL CIRCULATION	2147	2174

During this past month there were two corporations and eleven persons, not heretofore members, who joined this Society.

ROSTER CHANGES DURING JULY*

Corporation

Rookwood Pottery Co., John D. Wareham, voter, Mount Adams, Cincinnati, Ohio. (Stanley G. Burt, voter)

Personal

Burton, Howard B., Jr., 1319 Grand Ave., St. Paul, Minn. (Dayton, Ohio)
Cole, Sandford S., Titanium Pigment Co., Inc., P. O. Box 58, South Amboy, N. J. (Brooklyn, N. Y.)
Davidson, Harry H., c/o S. Chess, 8102 23rd Ave., Brooklyn, N. Y. (Mullite Refractories Co., Seymour, Conn.)
Goodrich, Hobert R., Gladding, McBean & Co., Glendale, Calif. (Lincoln, Calif.)
Hamburger, Herbert M., 417 25th Ave., South, Nashville, Tenn. (N. C. State College)
Linton, Robert, 605 Edison Bldg., Los Angeles, Calif. (Pacific Clay Products)
Lloyd, Arthur S., 417 25th Ave., South, Nashville, Tenn. (N. C. State College)
Longenecker, H. L., Cherokee Brick Co., Macon, Ga. (Raleigh, N. C.)
Lowe, G. Kenneth, Allerton Hotel, Cleveland, Ohio. (Cincinnati, Ohio)
McCann, F. A., 632 La Mirada Ave., San Marino, Calif. (Los Angeles, Calif.)
McDanel, Walter W., 1471 Fourth St., New Brighton, Pa. (532 Thirteenth St.)
Manson, M. E., Rundle Mfg. Co., Milwaukee, Wis. (Wauwatosa, Wis.)
Marbaker, Edward E., Mellon Institute, Pittsburgh, Pa. (Industrial Research and Engineering Co.)
Morgan, Raymond W., 1464 Winona Ave., Chicago, Ill. (Milwaukee, Wis.)
Pask, Joseph A., Willamina Clay Products Co., Willamina, Ore. (University of Washington)
Razey, Robert M., 100 South Ashland, Detroit, Mich. (Hornell, N. Y.)
Skinner, Kenneth G., Toppenish, Wash. (York, Pa.)
Wilson, Charles L., American Vitrified Products Co. Lisbon, Ohio. (Brazil, Ind.)
Zimmer, Harry, Porzellanfabrik, Waldershof, Oberpfalz, Germany. (Wheeling, W. Va.)

* Address in parentheses ( ) is the old address.

OUR MEETINGS SCHEDULE

Art Division, Syracuse, N. Y.—October 28 and 29.
Glass Division, Hammondsport, N. Y.—September 13 and 14.
Refractories Division, State College, Pa.—September 20 and 21.
Whitewares Division, Beach Haven, N. J.—September 5, 6, and 7.

38th Annual Meeting, Columbus, Ohio—March 29 to April 4, 1936

ART DIVISION FALL MEETING PROGRAM

The tentative program for the Fall Meeting of the Art Division of the American Ceramic Society, to be held in Syracuse, N. Y., Monday and Tuesday, October 28 and 29, 1935, during the Robineau Memorial Ceramic Exhibition is as follows:

(1) Ceramic Craft Work in Secondary Schools

(*a*) To what extent is it justified?
(*b*) Types of work which do most for children, particularly work which does not depend for its interest on glazes applied and fired by teachers (see also pages 276–77, this issue).
(*c*) Stimulation which would result if teachers were experienced and able craftsmen and in each community developed centers of ceramic art appreciation.

(2) Ceramic Art Education in Colleges

(*a*) Industrial art requirements.
(*b*) Teacher training requirements.
(*c*) Craftsman training requirements.

(3) Small Kilns for Craftsmen and Schools

(*a*) Firing equipment and procedure will be discussed.

(4) Methods of Stimulation of Ceramic Crafts

(5) Discussion of Prepared Ceramic Materials Which Would Aid the Craftsmen and Schools

It is planned to make the meeting a round-table affair, open to general discussion rather than to have a series of formal papers or addresses. It is thought that the greatest advantage to those attending will result from this form of program.

Those desiring to take part in the various discussions are requested to notify, as soon as possible, Division Chairman L. E. Barringer, General Electric Company, Schenectady, N. Y.; R. Guy Cowan, Onondaga Pottery Co., Syracuse, N. Y.; or Charles M. Harder, New York State College of Ceramics, Alfred, N. Y.

ROBINEAU MEMORIAL CERAMIC EXHIBITION AT SYRACUSE
CERAMIC CRAFTSMEN THROUGHOUT NATION TO EXHIBIT

The Fourth Annual Robineau Memorial Ceramic Exhibition will be held from October 15 to November 11, 1935, at the Museum of Fine Arts, Syracuse, N. Y., in honor of the late Adelaide Alsop Robineau, noted ceramist and editor.

After the Syracuse showing, a selected group from this exhibition is to be circuited by the College Art Association. Entries may include the work of any ceramic craftsman, provided it has not been previously exhibited at the Syracuse Museum.

Richard F. Bach, Director of Industrial Relations, Metropolitan Museum of Art, New York; R. Guy Cowan, Designer, Onondaga Pottery Co. (representing the American Ceramic Society); Carl Walters, Ceramist, Woodstock, N. Y.; and Philip N. Youtz, Director, Brooklyn Museum (representing the College Art Association) comprise the Jury of Selection and Award.

Two prizes are offered this year. Fifty dollars will be given for the best piece of pottery produced by a craftsman, to be judged on the basis of decorative, creative, and technical qualities. This is offered by the Onondaga Pottery Co. Another $50 prize is offered by the Trustees of the Syracuse Museum of Fine Arts for the best piece of ceramic sculpture.

All entries must be received not later than October 1, 1935. They must be sent to King Storage Warehouse, Inc., 755 North Salina St., Syracuse, N. Y., marked: For Robineau Ceramic Exhibit.

An entrance fee of $1.50 is charged; exhibitors are limited to five pieces each.

Information sheets setting forth the conditions of entering this Exhibition may be obtained by writing to *The Bulletin*, The American Ceramic Society, 2525 North High St., Columbus, Ohio.

For further information and entry cards, ceramists should write directly to Anna Wetherill Olmsted, Director, Syracuse Museum of Fine Arts, Syracuse, N. Y.

REFRACTORIES DIVISION SUMMER MEETING PLANS

Louis A. Smith, Refractory Engineer with Jones and Laughlin Steel Co., Aliquippa, Pa., will present a paper at the Refractories Division Summer Meeting to be held at Centre Hills Country Club, two miles southeast of State College, Pa., September 20 and 21, 1935.

Other metallurgists will also participate. The subject of the technical session will be "Present Problems and Trends in Refractory Requirements."

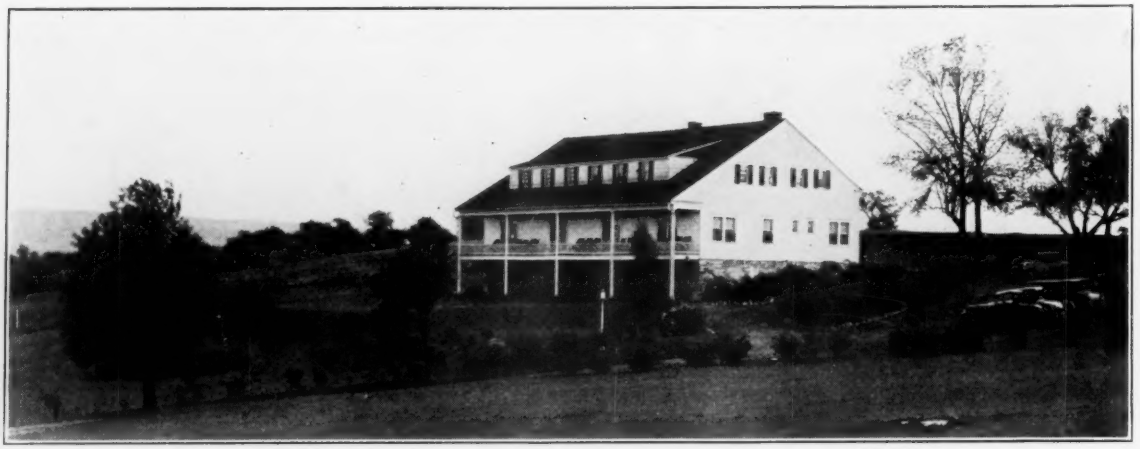
Harold E. Simpson, Ceramic Engineer, Battelle Memorial Institute, Columbus, Ohio, will present a paper on the subject of "Slagging of Fire Brick by Cold Ash Slags."

The Pittsburgh Section of the American Ceramic Society and Committee C-8 of the American Society for Testing Materials have been extended special invitations to attend this meeting.

General arrangements for the two-day session are as follows:

Friday, September 20

12:30 P.M. Luncheon at Centre Hills Country Club, two miles southeast of State College, Pa.
2:00 P.M. Technical Session, Centre Hills Country Club "Present Problems and Trends in Refractory Requirements"



Centre Hills Country Club, located two miles southeast of State College, Pa., will be the scene of the Summer Meeting of the Refractories Division of the American Ceramic Society, September 20 and 21, 1935.

8:00 P.M. Outing for "Pittsburgh Clay Workers Club" at Bear Meadows Clay Pits
Ladies Entertainment will also be provided for the evening.

Saturday, September 21

Golf, tennis, or swimming at Centre Hills Country Club, or informal excursions to nearby points, such as Fisherman's Paradise, Penn's Cave, Greenwood Furnace, or Shingletown Gap. Fees are as follows for the sports at the Country Club: golf, 75 cents, tennis, 25 cents, and swimming pool, 50 cents.

N. W. Taylor, Hobart M. Kraner, and Harold E. White are in charge of the meeting arrangements.

Accommodations

The Country Club can accommodate about twenty-five men overnight at $1.00. Meals for 125 persons can be provided there, breakfast costing 50 cents, luncheon 75 cents, and dinner 85 cents.

Accommodations at the Nittany Lion Inn, State College, Pa., cost from $2.50 up. Tourist accommodations in State College may be had for 75 cents a person.

LOCAL SECTION NEWS

CALIFORNIA SECTION HONORS RIDDLE

A special meeting of the California Section of the American Ceramic Society was held July 2 in honor of Frank H. Riddle, Director of Research, Champion Spark Plug Company, who is visiting on the Pacific Coast. A dinner was served to sixty-six members of the Local Section.

Following the dinner, Mr. Riddle gave a timely discussion based upon his observations of the new order of things in ceramics which he has found on the Pacific Coast.

The gathering later visited the Thomas S. Curtis Laboratories, where the members were shown some of the testing and research equipment in operation.

—THOMAS S. CURTIS, *Secretary*

MICHIGAN-NORTHWESTERN OHIO

A business meeting of the Michigan-Northwestern Ohio Section, was held at Mt. Clemens, Mich., June 17, 1935.

J. A. Callahan, General Manager, Plumbing Ware Division, Briggs Mfg. Co., spoke on the subject, "Pressed Steel Enamel Ware as Made by Briggs Co."

—MACON C. TRABUE, *Secretary*

CHICAGO SECTION TOURNAMENT

The Chicago Section of the American Ceramic Society held its Annual Golf Tournament on June 28 at the Medina Country Club, Itasca, Illinois. Nineteen members attended the tournament.

A business session followed, at which the Section officers were reëlected for the year 1935–36 as follows: *Chairman*, G. G. Hanson, Consolidated Feldspar Co.; *Vice-Chairman*, George Arras, The Quadrangle Manufacturing Co.; *Secretary-Treasurer*, H. V. Kaeppel, *Ceramic Industry; Councillor*, C. W. Parmelee, Dept. of Ceramic Engineering, University of Illinois.

Members of the Advisory Committee to the Department of Ceramic Engineering, University of Illinois are E. H. Van Schoick, Chicago Retort & Fire Brick Company, Ottawa, Ill.; J. W. Wright, Owens-Illinois Glass Co., Alton, Ill.; F. L. Steinhoff, Industrial Publications, Inc., Chicago, Ill.; William Schlake, Illinois Brick Co., Chicago; and Frank Hodek, General Porcelain Enamel & Mfg. Co., Chicago.

The treasurer's report showed that the Chicago Section is highly solvent with a balance of $296.61.

—H. V. KAEPPEL, *Secretary*

WILL YOU HAVE A PAPER READY FOR THE 1936 MEETING?

WHITE WARES DIVISION TO HOLD FIRST SUMMER MEETING

The first session of the first Summer Meeting in the history of the White Wares Division of the American Ceramic Society will start Thursday, September 5, with a luncheon at the Woodrow Wilson Hotel, New Brunswick, N. J. Following this, the group will spend the afternoon at the Department of Ceramics, Rutgers University.

Transportation will be furnished late Thursday afternoon to take the group from New Brunswick to Beach Haven where a 7 o'clock dinner will be served at the Engleside Hotel.

On September 6 and 7, the Engleside Hotel, Beach Haven, N. J., will be the scene of the meetings. Informal technical sessions are planned to be held at Beach Haven on Friday and Saturday mornings. The afternoons and evenings are to be devoted to entertainment.

Subjects for Discussion

"Firing in the Whiteware Industry," "Cast Saggers in the Whiteware Industry," and "Daily Control of Manufacturing Processes to Obtain a Uniformity of Product" are the subjects to be discussed.

Informal reports on electric, gas, oil, producer-gas, and coal-fired kilns and a discussion of proposed terms and definitions will be included under the subject of firing.

The merits and problems connected with the subject of cast saggers should be of interest. This type of sagger is comparatively new in the industry.

The matter of daily tests to insure uniformity of product is one of vital interest to the entire industry, and while every plant and manufacturer of each type of product has individual problems, it is felt that many tests must be applicable to other products with equal advantage. New equipment for control will also be discussed. All interested ceramists are invited to attend this meeting and take part in the discussions of these problems.

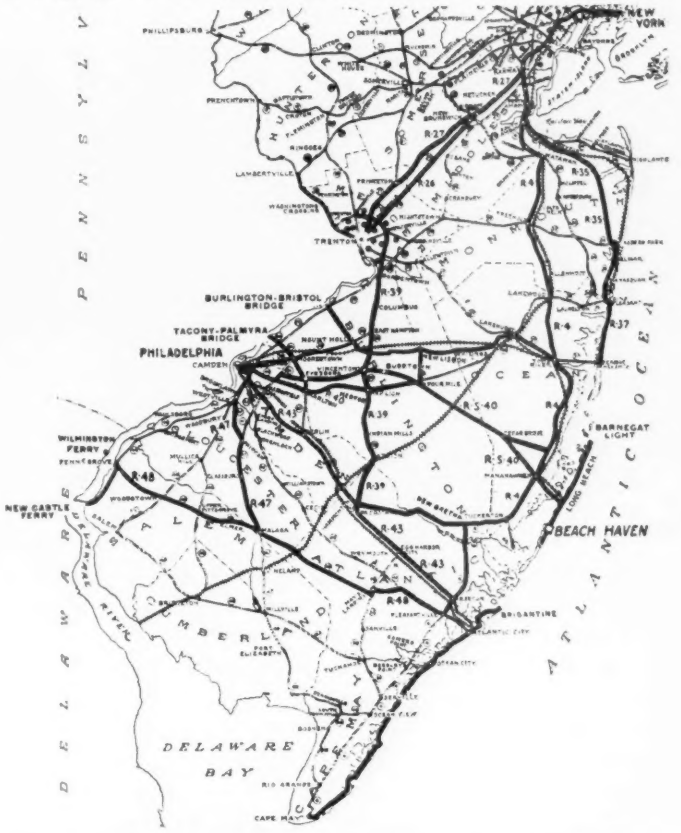
Members of the Ceramic Association of New Jersey are cordially invited to attend. Rates at the Engleside are $4.50 per day, single with running water, $5.00 single with private bath, American plan.

W. Keith McAfee, Universal Sanitary Mfg. Co., New Castle, Pa., is General Chairman of this meeting and S. J. McDowell, General Ceramics Co., Keasbey, N. J., is Technical Program Chairman.

The committee in charge of local arrangements consists of *Chairman* George H. Brown, Department of Ceramics, Rutgers University, and V. V. Kelsey, Consolidated Feldspar Corp., Trenton, N. J.

Early reservations at the Engleside Hotel are suggested. Bathing suits, fishing tackle, tennis rackets, and so forth, should be brought.

HOW TO REACH BEACH HAVEN



The routes to Beach Haven from many points in the East are shown on the accompanying map. To reach Beach Haven from New York: Motor over route 4 along the Ocean Highway, through Toms River and Barnegat; turn left at Manahawkin; cross free causeway over bay. From Philadelphia: Over Delaware River, Palmyra, or Bristol Bridges into Medford, thence on highway S40 into Manahawkin and across free causeway over Bay.

HAMMONDSPORT, NEW YORK, HEADQUARTERS FOR GLASS DIVISION MEETING SEPTEMBER 13 AND 14, 1935

Jess Littleton and his associates will not be drowned out. Keuka Hotel and the pavilion at Keuka are wrecked as a result of the recent New York floods.

For this reason the Summer Meeting of the Glass Division scheduled for September 13, 14, and 15, 1935, will be held at Hammondsport, N. Y., at Firemen's Hall where the meeting was held last year.

Jess Littleton will have more cottages available at Willow Point. The Hammondsport Hotel can take care of those twenty-five persons who are too proud to bring their own bed linen and blankets.

There are tourist homes and, for those who insist, parsonages. The boarding rates, entrance fees, and shore dinner reservation blanks will be mailed on request. Address the Society's Executive Office, 2525 N. High St., Columbus, Ohio.

MECHANICAL STRENGTH OF GLASS AND ITS RESISTANCE TO THERMAL SHOCK*

By J. S. Gregorius

The papers to be presented at the Summer Meeting of the Glass Division of the American Ceramic Society have for their scope the mechanical strength of glass and its resistance to thermal shock. It is to be hoped that these presentations will tend to clarify the definition and produce the groundwork that will, at least, initiate a common expression of values with the ultimate development of a standard technique of testing. The difficulties attending the immediate realization of this goal are properly recognized, and it is hoped that such recognition will in itself be the greatest force in guiding us to a satisfactory conclusion.

Glass fails or breaks when an applied stress exceeds its strength. Materials have compressive and tensile strengths which are not identical. The compressive strength of glass is, possibly, seventeen times greater than its tensile strength. This ratio may be even larger. To produce in a test specimen compressive stress with no counterpart of tensile stress requires that the object be compressed in a liquid medium. No commercial application of glass faces this condition. Any application of stress developed either mechanically or thermally, which bends, twists, or otherwise distorts the specimen, will produce tensile as well as compressive stresses. Hence glass failures or breaks can be assumed to occur always from a tension failure. From this consideration it becomes apparent that the most pertinent need is for a method of determining accurately the tensile strength of glass.

The application of tensile strength may be quite easily accomplished. This being granted, the selection of the form and conditions of the specimen and technique of testing becomes important.

Influence of Thermal History

The rate of temperature drop through the critical annealing range determines the magnitude of strain existing in the specimen at room temperature. This residual stress in a flat specimen at rest would be compression in the skin layers and tension in the core. Such a distribution would mean that in any bending test the force applied would first have to nullify the skin compression before the intrinsic strength of the glass would be involved. Should not the magnitude of residual stress in the test specimens be defined?

Chemical Heterogeneity

Poorly mixed or improperly melted glasses show evidence of chemical heterogeneity. This heterogeneity makes controlled annealing difficult. Should not a definition of tolerable heterogeneity be made?

Continuity of Surface

The well-known ability of a hardened steel wheel or a diamond to score glass, thus making breaking easy, emphasizes the need of selected test specimens. Should not test specimens be free of chips, spalls, vents, and the like? Should they be specified as ground, polished, or fire-polished?

Ratio of Surface to Mass

A fiber has a higher apparent tensile strength than a rod of the same material. A lath of a given breadth, length, and thin section has a higher apparent modulus of rupture value than a lath of similar breadth and length but with a thicker section. Does this not open a wide field of speculation? Does the skin structure of glass differ from the structure under the surface?

Rate of Load Application

Does fatigue enter into strength of glass? Does an instantaneous application of force give a lower or higher strength value than a slow application of force? Answers to these questions are necessary in establishing the proper technique of testing.

These may be only a few of the thoughts that occur in connection with this problem, but surely there is unanimity in the thought that the properties of mechanical strength of glass and its resistance to thermal shock are of close kinship and that there are many manifestations of irregularity

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* An introduction to the problems which will be considered at the Summer Meeting of the Glass Division of the American Ceramic Society, Hammondsport, N. Y., September 13 to 15, 1935. Received July 13, 1935.

of these properties that disturb our mental composure.

Should the 1935 Summer Meeting of the Glass Division initiate steps that will lead to the development of acceptable methods of test and interpretation, the effort will be commendable and the reward of accomplishment high.

RESEARCH LABORATORIES
PITTSBURGH PLATE GLASS CO.
CREIGHTON, PA.

GLASS DIVISION SUMMER MEETING PROGRAM

ABSTRACTS OF PAPERS

1. The Effect of Sustained Loading on the Strength of Electric Lamp Bulbs

By F. W. Preston, Butler, Pa.

The effect of time and load on the strength of electrical lamp bulbs is discussed. Observations directed to determining the conditions affecting strength in an object, the shape of which is spherical, or approximately spherical, over the critical area are also made.

2. The Effect of Sustained Loading on the Modulus of Rupture of Flat Glass

By L. V. Black, Pittsburgh Plate Glass Co., Creighton, Pa.

This paper endeavors to show the effects of different rates of force application on the breaking strength of glass. The modulus of rupture is determined when the average load necessary to break a given specimen is applied at rates ranging from 10 seconds to 40 minutes. The effect of fatigue on the strength of glass is also investigated.

3. Strength of Flat Glass under Uniform Loading

By George B. Watkins and R. W. Wampler, Libbey-Owens-Ford Glass Co., Toledo, Ohio

Break tests have been conducted on flat glasses in both square and rectangular shapes by uniform loading (hydraulic). Data thus obtained may serve as a guide for determining the proper size and thickness of glass when used structurally.

4. Proposed Method for Measuring Tensile Strength of Glass

By C. J. Phillips, Corning Glass Works, Corning, N. Y.

An improved cantilever bending device with double loading edges is described and has been used for measuring the tensile strength of borosilicate glass cane drawn without marvering. Results are given for groups of samples which were abraded, highly polished, untouched, and treated in the ordinary way. Although the initial stresses and loading rates were adjusted to the same basis, the presence of surface imperfections is shown by overall maximum to minimum stress variations from 26.0 to 167.0%.

5. Some Factors Affecting the Impact Strength of Glass

By James Bailey, Bailey & Sharp Co., Inc., Hamburg, N. Y.

The general use of glass for protection purposes both in moving vehicles and in goggles has made necessary certain impact tests for sheet glass. These usually take the form of tests wherein a steel ball is dropped through a certain height upon the glass to be tested. The energy required to break the glass is not constant but depends upon several factors such as the kind of support, the size of the ball, the stiffness of the glass, etc. A small ball moving at high velocity causes a conchoidal fracture driven through from the top side; a large ball with slow velocity causes failure in pure tension at the lower side. With large thin sheets and moderate velocity of impact the chief resistance to movement is caused by the inertia of the glass itself, and the character of the edge support is no longer a factor. The investigation was confined to commercially annealed sheet glass.

6. Modulus of Rupture and Thermal-Shock Resistance at Elevated Temperatures

By J. S. Gregorius, Pittsburgh Plate Glass Co., Creighton, Pa.

The modulus of rupture of glass was observed at room temperature and at intervals up to 1000°F. The resistance of specimens to thermal shock was observed when the chilling medium ranged from 200 to 1000°F. Interpretations are drawn from the data observed.

7. Thermal Endurance of Different Types of Flat Glass with Relation to Thickness

By R. W. Wampler and George B. Watkins, Libbey-Owens-Ford Glass Co., Toledo, Ohio

Thermal-shock tests have been conducted on 3-inch squares of different types of flat glass by quenching samples in water at 32°F from a predetermined elevated temperature. Attempts have been made to correlate data thus obtained with heat-absorption characteristics and thermal expansion coefficients.

8. The Influence of Various Heating and Cooling Media on the Severity of Thermal Shock on Glass

By C. R. Hunter, Owens-Illinois Glass Co., Alton, Ill.

In order to determine the severity of thermal shock in its relation to the various substances employed in heating and cooling the glass, the following liquids were used: water, glycerine, ethylene glycol, and several oils. Further tests were made from hot air to cold air and hot air to cold water. The protective action of the hot liquid film adhering to the surface of the specimen was checked by comparing the relative severity of shock of two oils having the same thermal properties but different vis-

cosities. In all cases a 50% breakage level was used for comparison.

9. **Influence of Various Factors on the Results of Thermal Shock Tests**

   By G. R. Hunter, England

10. **Review of Recent Literature on Strength of Glass under Sustained Loading with Particular Reference to Borchard's Work**

    By J. T. Littleton, Corning Glass Works, Corning, N. Y.

Breakage of glass has been considered to take place as soon as a certain stress has been attained, or as soon as a certain strain is acquired. Results are cited which show that glass under sustained load breaks at about 50% of the stress which would be required at short time loads. This result is explained by the flowage in the glass under load, the flowage being greater around flaws than elsewhere.

JOINT COMMITTEE ON ILLUMINATING GLASSES RE-APPOINTED

The 1934 Joint Committee of the Glass Division of the American Ceramic Society and the Illuminating Engineering Society on Illuminating Glasses has been re-appointed for 1935 by U. E. Bowes, Chairman of the Glass Division.

The members of the Committee are as follows:

H. H. Blau, Macbeth-Evans Glass Co., Charleroi, Pa.
R. A. Miller, Pittsburgh Plate Glass Co., Pittsburgh, Pa.
A. N. Finn, National Bureau of Standards, Washington, D. C.
R. R. Shively, B. F. Drakenfeld Co., Washington, Pa.

The Illuminating Glassware Guild works in coöperation with the above groups.

McDOUGAL'S KILNS FIRE SPARK PLUGS SATISFACTORILY

In a letter from the General Secretary to K. E. Rogers, Globar Corp., Niagara Falls, N. Y., in regard to the firing of ceramic ware with electricity, the following statement was made:

The A C Spark Plug Company's kiln is decidedly a toaster, so much so that they get a difference of 12 cones over a small kiln cross-section. True it is that this kiln has served its purpose by adequately firing the tip or "business end" of their plugs.

The following letter, dated July 18, 1935, has been received from A. H. Fessler of the A C Spark Plug Company addressed to the General Secretary:

"Your statement in the circular letter dated December 14, 1934, and addressed to K. E. Rogers of the Globar Corporation, is in error in the reference to our tunnel kilns since we do not use electricity in firing our insulators. Both insulator kilns are fired with butane gas.

"Your statement that a difference of 12 cones exists in our production kilns is very much in error, since we find less than $^1/_4$ cone variation from one side of the car to the other. This variation in temperature applies also to the difference found between the tip and bottom of the insulators. The cone study has been verified by passing thermocouples through the kilns. These indicate practically no difference at the maximum temperature."

NOTES AND NEWS FOR CERAMISTS

A. S. T. M. TO HOLD 1936 ANNUAL MEETING AT ATLANTIC CITY

The American Society for Testing Materials will hold its Thirty-Ninth Annual Meeting in Atlantic City, N. J., from Monday, June 29, to Friday, July 3, 1936.

The Regional Meeting and Group Meetings of the A. S. T. M. Committees will be held in Pittsburgh, Pa., during the week of March 2 to 6, 1936.

—C. L. WARWICK, *Secretary-Treasurer*

Fellowships Established at Ohio State Experiment Station

The United States Potters Association has established a research fellowship in whiteware problems at the Engineering Experiment Station of Ohio State University.

A group of manufacturers in the Oak Hill district also has established a fellowship in refractories there.

The Society of Rheology to Meet October 11 and 12

The Seventh Annual Meeting of the Society of Rheology will be held in New York, N. Y., at the Bell Telephone Laboratories, October 11 and 12, 1935.

Special features of this meeting will be the two symposia on the rheological aspects of rubber and plastics. The Committee in charge of the development of the plastics symposium is E. O. Kraemer, Marshallton, Del., and H. A. Wakefield, Bakelite Corp., Bloomfield, N. J. The rubber symposium is being developed by Melvin Mooney, U. S. Rubber Products Co., Passaic, N. J., and J. W. Dillon, Akron, Ohio.

In addition, a general symposium on rheology subjects is being developed by E. C. Bingham, Lafayette College, Easton, Pa., and A. Nadai, Westinghouse Electric and Mfg. Co., East Pittsburgh, Pa.—A. S. HUNTER, *Secretary*

NEWS OF MEMBERS

Felix Singer Is Consultant for United States Stoneware Company

Felix Singer has recently been retained as Consulting Ceramic Engineer by the United States Stoneware Co., Akron, Ohio, manufacturers of chemical stoneware and corrosion-proof equipment.

Dr. Singer studied chemistry, physics, and ceramics in Germany and holds the degrees of Doctor of Science and Doctor of Philosophy from the Universities of Berlin and Erlangen. He is known for his many scientific and technical contributions to ceramic literature, as well as for his research leading to the development of chemical stoneware for many new uses. Many special stoneware bodies have been developed by Dr. Singer.

Andrews Visits European Countries

A. I. Andrews of the Department of Ceramic Engieering, University of Illinois, sailed July 31 for Europe to visit Austria, France, Germany, England, and Czechoslovakia as a representative of an American manufacturer of ceramic materials.

Bole Awarded Degree by Geneva College

G. A. Bole, Research Professor, Engineering Experiment Station, Ohio State University, and Manager of the Edward Orton, Jr., Ceramic Foundation, Columbus, Ohio has been awarded the degree of Doctor of Science by Geneva College, Beaver Falls, Pa.

Carruthers Presents Paper Before Mechanical Engineers

J. L. Carruthers, Department of Ceramic Engineering, Ohio State University, delivered a paper at the semi-annual meeting of the American Society of Mechanical Engineers held in Cincinnati, Ohio, June 19, 1935. "Drying Problems of the Ceramic Industry" was the title of the paper.

Schneider Heads North State Feldspar Corporation

Henry R. Schneider, a member of the American Ceramic Society, was elected president of the North State Feldspar Corporation, Micaville, N. C., June 15, according to an announcement received from that Company.

Attend Illinois Glass Conference from Ten States

At the Third Conference on Glass Problems at the University of Illinois, May 31 to June 1, 1935, ten States were represented as follows: Illinois 23, Ohio 15, Indiana 11, Missouri 5, New York 5, Maryland 2, Michigan 2, Pennsylvania 4, Connecticut 1, and Arkansas 1.

Refractory References Published by Litinsky

"Feuerfest-Kartothek" (Refractory References), a bibliography of all the refractory literature of the world for the years 1920 to 1934, including articles, books, patents, publications of firms, data, etc., has been issued by L. Litinsky, Leipzig O 27, Thieme Strasse 6, Germany. This work consists of 25,000 cards, $4^1/_4$ by $5^7/_8$ inches, with a cross-index of over 3000 words.

Litinsky is known for his publications on refractories and his journal, *Feuerfest*, replaced in 1934 by the Referatkartei der Silikatliteratur (reference bibliography of silica literature), and other publications.

Through this bibliography, the status of the refractory science and technology is made available in convenient form. The material is divided into more than 200 groups and subgroups and is fully cross-indexed. Each card contains information as to the contents of the publication named; re-publications are noted and reviews of publications are listed. The cost, according to the prospectus, for the total bibliography is 1800 M, postage extra.

Ohio Ceramic Industries Association Division Officers

A. A. Wells, Homer Laughlin China Co., Newell, W. Va., was elected Chairman of the Whitewares Division, Ohio Ceramic Industries Assn., for the coming year. J. W. Hepplewhite, Edwin M. Knowles China Co., Newell, W. Va., was elected Vice-Chairman of this Division.

R. L. Beck, Cleveland Brick & Clay Co., Cleveland, Ohio is the new Chairman of the Heavy Clay Products Division of the Association. R. E. Arnold, Robinson Clay Product Co., Akron, Ohio, is Vice-Chairman of this Division.

Cast-Iron Enamel Matches Sheet-Iron Enamel

Porcelain Enamel & Manufacturing Co., Baltimore, Md., has announced a new series of lead-free cast-iron enamels which are said to be a perfect match in whiteness for sheet-iron enamels.

Previously there was a distinct difference between the shades of white for porcelain enamels for cast iron and those for sheet iron, the enamels on cast iron usually being yellow or gray and lacking the opacity of sheet-iron enamels.

Primitive pottery of various types is included in the ceramic collection at the Louisiana State Museum, New Orleans.

TEACHING POSITION OPEN

Teaching Position and Research; associate professorship or professorship in ceramics department of technical school, Middle West, heavy clay goods and refractories. Salary and rank dependent on qualifications. Address inquiries to The General Secretary, The American Ceramic Society, 2525 N. High St., Columbus, Ohio.

COMMUNICATIONS—CERAMIC HISTORY

CERAMISTS AT UNIVERSITY OF ILLINOIS STUDY EFFECTS OF ALUMINA IN GLASS

The study of the effects of alumina in glass was the chief topic in the glass research program conducted during the past year by the Department of Ceramic Engineering, University of Illinois, it was reported at the Third Conference on Glass Problems (May 31 to June 1, 1935, Urbana, Ill. See *The Bulletin*, p. 214 (June, 1935).

Seven men have been engaged in measuring some important physical properties of such glasses: thermal expansion, surface tension, scratch-hardness, tensile strength, and rate of melting.

Precise measurements of thermal expansion have been made with an interferometer. Although the results are incomplete, they indicate that a small addition of alumina to a soda-lime glass results in a decreased thermal expansion and an increased annealing temperature of the glass.

The surface tension of molten glass is often not considered, although it affects the working properties of glass and its rate of fining. For measuring surface tension, the so-called "maximum-bubble-pressure" method has been used, by which the surface tension is deduced by measuring the pressure in a bubble which is blown from the tip of a small platinum tube immersed in the molten glass. Measurements with this apparatus are accurate to about 0.5%.

Results of tests show that the surface tension of glass decreases slowly as the temperature rises. In regard to the effect of alumina, it was found that the surface tension is increased by additions of this substance to a soda-lime glass, the increase being about 7% for an addition of 2% alumina.

Another property of glass which is very important from the standpoint of practical usage, is surface hardness or resistance to scratching. Accurate measurements of this property are rare and the results of different observers are not easily compared.

In order to determine the surface hardness of glasses, an instrument is used which pulls a diamond point over the glass surface under definitely controlled conditions. The scratches on the surface thus produced range in size from those of microscopic dimensions to scratches which are easily visible to the naked eye.

The surface hardness values of many different types of glasses, as well as those of several minerals, have been measured with this instrument. The sensitivity of the apparatus is sufficient to detect the effects of various treatments on the same glass. Measurements of surface hardness differentiate, for example, between rough-rolled and smooth-rolled glass or between acid- and rouge-polished glass. The presence of alumina in glass tends to increase the surface hardness.

Tensile strength measurements of glass are complicated by the inherent brittleness of this material as well as by other factors. In the design of the apparatus used to obtain the tensile strength of glass, attempts have been made to avoid these difficulties.

The glass sample in the form of a fiber about $^1/_{16}$ inch in diameter and 6 inches in length, is loaded to the breaking point in a special manner. After rupture of the fiber occurs, the fractured section is examined under the microscope. Work, which is now in progress, is aimed at deducing the true tensile strength of glass from such measurements.

The effect of alumina additions on the melting rates of glasses is the subject of a research which has just been completed.

A soda-lime-magnesia glass was chosen for study, alumina being added to the batch. The melts were made in platinum crucibles, the temperature of which was accurately controlled. Microscopic examination was used to show when melting of the batch was completed.

It was found that, if the batch was held at low temperatures (about 1200°C), the addition of alumina produced a slower melting glass. At higher temperatures (about 1350°C), however, the melting time of a glass batch containing alumina was only slightly greater than the alumina-free glass batch.

The above studies have been concerned with glasses of commercial compositions. In another research, glass melts have been made with compositions differing widely from commercial practice. The object of these tests was to determine what field of glass compositions could be melted at ordinary furnace temperatures of 1400 to 1450°C (2552 to 2732°F). The oxides Na_2O, K_2O, CaO, MgO, Al_2O_3, B_2O_3, and SiO_2 comprised the field of study.

Thermal expansion is the only physical property of these abnormal glass compositions which has been investigated up to this time and the results are incomplete.

—C. W. PARMELEE, *Head of Department*

THE SCALE OF EXPERIMENTATION

BY S. I. PERKAL

Many investigators are aware that results successful in the laboratory using small quantities of matter or small-sized apparatus can not always serve as the basis for judging the success with which the experiment will be repeated on a large or even medium scale. It is also true that failure of an experiment on the laboratory scale is not a true indication that the idea is impracticable for commercial adaptation when the experiment is repeated on a large scale.

An interesting illustration of this latter fact is given by

Frank J. Tone[1] in telling of the development of elemental crystalline silicon carbide probably as the result of the reaction $SiO_2 + 2C = Si + 2CO$ or $SiO_2 + 2SiC = 3Si + 2CO$.

Experiments showed that though both reactions produce silicon, with a charge of silicon carbide (SiC) and silica (SiO_2) the operation was steadier and easier to control and the output was much greater.

In a laboratory furnace, the continuous production of silicon metal was hardly possible. In a 500 h. p. furnace most of the difficulties disappeared although it was necessary to work with a charge of silicon carbide and silica. When the size of the furnace was increased to 1200 h.p. and later to 4000 h.p., the difficulties disappeared and it was possible to work with a straight charge of silica rock and coke.

Thus, in some fields, Mr. Tone concludes, the laboratory worker is at a disadvantage in making new discoveries.

Another example is found in the manufacture of electrically fused corund from alumina or bauxite or other alumina materials when this process is carried out by fusing a lump of the material which is allowed to set *in situ* and the resulting product is crushed and ground. It has been found that the greater the lump the better is crystallization of the product. This would seem to indicate the value of installing bigger furnaces and fusing greater lumps of the material.

It would be interesting if readers would give other fundamental examples illustrating the same point, namely, that sometimes the results of an experiment carried out in the laboratory are not an adequate indication of the value of a similar experiment with larger scale apparatus and more material.

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[1] Frank J. Tone, "High-Temperature Products of Silicon," *Ind. Eng. Chem.*, **23,** 1312–16 (1931).

NORTH DAKOTA PLANS STATE-WIDE CERAMIC ACTIVITIES

University of North Dakota Students Work with All-Native Materials

Climaxing twenty-five years of work at the University of North Dakota, Grand Forks, N. Dak., Margaret Cable, who has charge of both the clay testing and the ceramic courses offered at the University, has announced plans for testing North Dakota clays to determine their possible uses in connection with ceramic educational activity throughout the State in both elementary and high schools.

Various local groups will assist in gathering clays in each section of the State and forward them to the University at Grand Forks for testing.

After the workable clays have been chosen in each vicinity, extension work will be carried out by teaching interested groups in various parts of the State to make pottery using simple methods, such as coil building, and methods of firing similar to that practiced by the Amerindians.

An example of the proposed technique is as follows: When the shape is finished, the potter polishes the piece after the manner of the Amerindian potters, and then packs the piece in sawdust in a metal container, such as an old oil drum. The can is then set on brick above a wood fire and fired until the can is red hot (about four to five hours). The resulting piece has a burnished black surface and is said to be one of the most attractive finishes available to the amateur potter with little equipment and no facilities for making or firing glazes.

This is the latest of a long series of projects through which Miss Cable and the University have served North Dakota ceramists. For years, clay samples from all over the State have been tested for various industries and, in addition to her activities at the University, Miss Cable has lectured extensively throughout the State before various groups.

Representative collections of the work done under the direction of Miss Cable are sent to groups requesting them. A lecture is generally sent with this material and, if funds are available, Miss Cable may also accompany the exhibit, taking her potter's wheel and giving a demonstration of throwing.

As a means of financing some of the personnel in the department, ceramic pieces are also made and sold. Among the most recent commissions completed there are the 250 Parent-Day plaques which were presented to parents of University Seniors who visited the University as guests of the University. The prairie rose was the motif of this piece, and the plaques were glazed in a range of colors. A series of 250 paper weights with the design of the P.E.O., a secret organization of women, was also completed in the late spring. These were designed to be sold as souvenirs at the September meeting of this group in Yellowstone National Park. In addition, 500 small nut cups were thrown on the wheel by Miss Cable and fired and glazed in various colors. These were designed for the North Dakota table at this same meeting.

One of the largest assignments this year was that of making 1500 American Legion plaques, which were used as the official badge of the Legion at the State convention. These carried the Legion emblem and were dry-pressed and glazed in copper and blue.

During the year, Miss Cable had an enthusiastic evening class of ten local business men who found a genuine interest in pottery making as a hobby. They were encouraged to work with native motifs, the Indian and cowboy themes and native flowers being among the predominant types of design material used.

Characteristic of the ingenuity with which these enterprises are planned and carried out are the native materials which are used almost exclusively in the work of the pottery students under Miss Cable's direction.

Both bodies and glazes are made from native materials. The bodies are mainly mixtures of the more workable of the fire clays found in abundance in North Dakota. For glazing, Freida L. Hammers, after about a year's experimentation, achieved a most attractive glaze which fires to a reddish, opaque finish. This is produced from North Dakota bentonite. As a variation of this color, an addition of zinc oxide gives a silvery cream color, and manga-

nese oxide gives a soft, blackish shade. With this limited pallet, the artists are able to center their attention on their designs without confusion.

The work offered in this department includes a history of pottery, and courses in throwing, glazing, hand-building, and modeling. In the first year, a beginning course is offered, in which throwing, molding, and casting are presented. After this, the students may specialize, following the type of work which most appeals to them.

Reports Invited

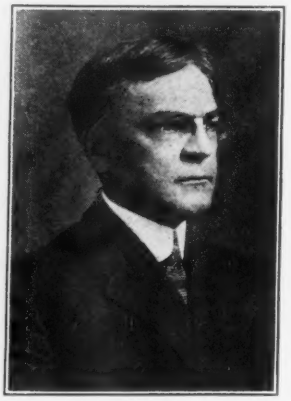
Reports from other States in which such enterprise is being shown will be welcomed by *The Bulletin*.—H.H.S.

JEPTHA LEE HOLTON: PIONEER GLASS SCIENTIST*

By Alexander Silverman

A number of articles have appeared in glass journals recently which pay tribute to pioneers in various branches of glassmaking. In this connection, one should not overlook the early scientific work of Jeptha Lee Holton on illuminating ware.

Mr. Holton was born in Indianapolis, Ind., April 2, 1864. He entered Princeton University, a member of the class of 1887. His devotion to an invalid mother during his Senior year meant the sacrificing of his degree.



Jeptha Lee Holton

In 1888, Mr. Holton was employed at the Acme Glass Works (later Gill Brothers Company) of Steubenville, Ohio, where he acquired experience in the various phases of glassmaking until 1895. He specialized in the chemistry of glass, insofar as this was taught at the time, during the summer of 1895 at Harvard. He not only covered everything that was available in the English literature, but also arranged for translations of foreign articles. His wife, Anne W. Holton, now residing in Providence, R. I., had mastered French and through her coöoperation the important French volumes were at his command.

It has been the writer's good fortune not only to have been associated with Mr. Holton during the early part of the present century, but to have had access to his records. These include the various types of glass manufactured in day and continuous tanks and an endless variety of special glasses that were made in closed pots, such as the opals and the alabasters; copper, gold, and selenium rubies; yellows and ambers; greens, from the yellowish tone through the blue; and the latter into the deep cobalts, amethyst, and black. He developed a number of cased glasses, such as the green and white student lamp shades and cased opals and was informed on the simpler methods available in his day for roughly checking coefficient of expansion to utilize pairs of glasses which would work well together and minimize breakage. He was able to silver glass with a variety of reducing agents and had command of etching processes, including the gaseous, liquid, and powder methods. His interests also entered the field of enameling and decorating, and later, when the heat-resisting glasses were produced in Jena, Germany, he manufactured an excellent one himself in crystal and subsequently in colors.

Mr. Holton's gracious personality endeared him to other glassmakers and his batch books contain innumerable formulas developed by the leaders of his day, a number of whom are still looked up to as master color makers of our time.

At Gill Brothers, Mr. Holton utilized the scientific knowledge which was then available. He not only encouraged experimentation, but he availed himself of the newer ideas in the field of illuminating engineering, conferring with such individuals as Bassett Jones and Norman MacBeth. His company was among the first to offer illuminating ware on the basis of proper light distribution.

While a small six-pot experimental furnace was being built, Mr. Holton's versatility again became evident. He was thoroughly familiar with furnace design and with comparatively little effort converted a large glory hole into the experimental furnace. His decision was final in the design and construction of tanks and pot furnaces. He knew the proper clay mixes for various purposes, namely, blocks, pots, rings, etc. He utilized a number of types of iron and alloys in molds, according to their particular purpose and prepared his own composition for lining paste molds. He devised novel units for transferring articles to the leers and for conveying them through the annealing ovens.

Nor did Mr. Holton confine himself to the fundamentals of glassmaking and the scientific developments of his day, for he was a keen student of art. He was one of the first to apply classic and modern art to globes, shades, and bowls. His Grecian bowls are as beautiful as any that were ever designed. The selection of a trade name for an article was not a mere chance with him. When an alabaster glass was developed which had many desirable light-distributing properties and which resembled an exquisite white marble, he named it "Parian" after the famous Parian marbles.

With his untiring effort and his endless ambition, Mr. Holton failed to realize the limits of his physical endurance. About 1917, he suffered a paralytic stroke and though ever hopeful of recovery died February 2, 1920. Though late, it is only fitting that we pay tribute to a colleague who was a pioneer in the appreciation of science and art in the field of glassmaking and who became an important executive, as he was vice-president of Gill Brothers Company for many years preceding his death.

Department of Chemistry
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Pittsburgh, Pa.

* Received July 23, 1935.

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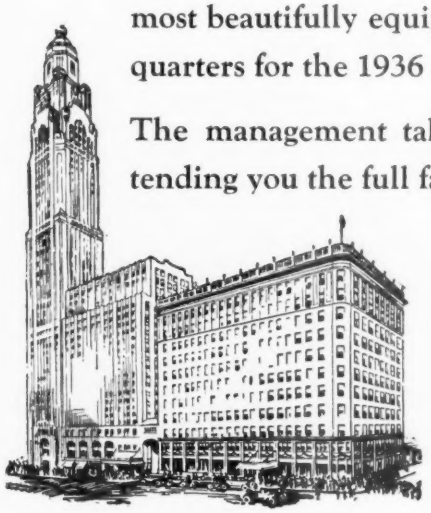

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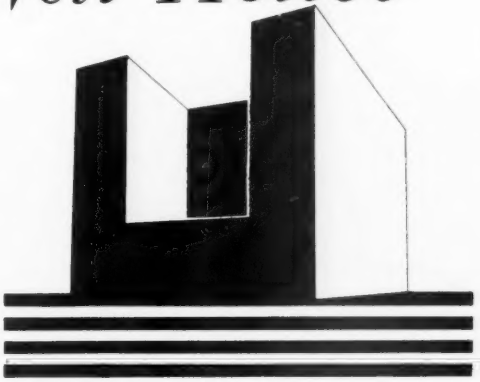

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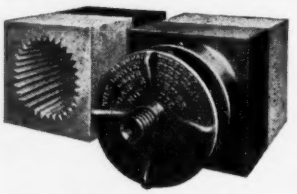

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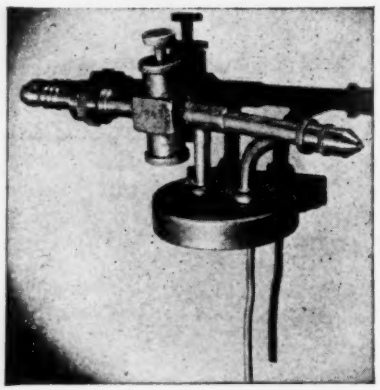

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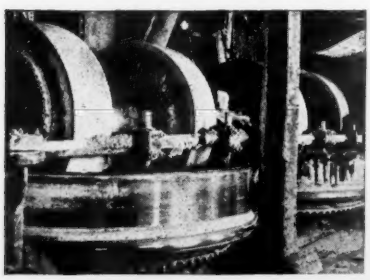

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NEWPORT, KY.

July 8, 1935

Mr. Pete Potter
Comfortable Sanitary Pottery Mfg. Co.
Pottsville, Ohio

Dear Pete:

You are right, Pete the air is sure full of economic, social and political ideas. Soak the rich! Share the wealth! Roosevelt saved the country and now who is going to save Roosevelt? Don't worry about this stuff because all it means is higher taxes, but you will be able to pay 'em because your business is going to be better. It's better right now! Stick to your potting. Make all the savings you can. Use more Spinks' Clays and your savings in moisture content and the increase in the percentage of first grade ware will be just like an increase in your selling price, and too, Pete, this is the time of the year for a vacation and you can leave the plant with ease and comfort because you know that those Spinks Clays are right and they'll stay right.

Have a good time, but don't get sunburned.

Sincerely,

Dick Carothers

Specialists in Opacifiers

FOR many years, the Metal & Thermit Corporation has held a prominent place in the ceramic industry. Hundreds of firms, including many of the largest plants in the country, use M & T Tin Oxide and M & T Sodium Antimonate, exclusively. More than that, these same firms call frequently on the Ceramic Department of the Metal & Thermit Corporation for help in solving technical problems.

Extensive research and continuous development by the company have created a vast fund of practical knowledge and experience to draw upon in meeting the many problems which arise, not only in the manufacture, but, equally important, in the application of its products. M & T technicians and representatives, long familiar with every phase of such work, have become veritable "specialists in opacifiers."

Metal & Thermit Corporation

120 BROADWAY, NEW YORK, N. Y.

CERAMIC DEPARTMENT

Homer F. Staley . . . . . Manager
R. R. Danielson . . Director of Research